Vol. 27 [illegible], 1934

JOURNAL
OF
ECONOMIC ENTOMOLOGY

Official Organ American Association of Economic Entomologists

E. Porter Felt, *Editor*
D. M. DeLong, *Associate Editor*
A. I. Bourne, *Business Manager*

Advisory Committee

H. S. Smith — W. H. Brittain — H. C. Huckett
A. G. Ruggles — C. A. Weigel — F. L. Thomas

Published by
American Association of Economic Entomologists
Geneva, N. Y.

Entered March 14, 1921 as second-class matter at the Post-Office at Geneva, N. Y., under the Act of Congress of March 3, 1879.

JOURNAL
OF
ECONOMIC ENTOMOLOGY
OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
VOL. 27 APRIL, 1934 No. 2

The Proceedings of the Forty-Sixth Annual Meeting of the American Association of Economic Entomologists (*Continued*)

Papers Read Thursday Afternoon, December 28, 1933 (Continued)

SEED TREATMENTS FOR CONTROL OF ROOT MAGGOTS[1]

By HUGH GLASGOW, *Geneva, N. Y.*

In the control of the root maggot (*Anthomyia brassicae*), attacking cruciferous crops, certain mercury salts are perhaps the most effective insecticides in common use. While the soluble salts of mercury, particularly corrosive sublimate, are extensively used in combating this pest, some of the insoluble compounds such as calomel and the oxides of mercury have been found equally effective, and in some cases considerably less toxic to the plants under treatment.

During the course of some preliminary tests with a number of these insoluble mercury salts to determine their relative safety to young plants, cabbage seed was treated immediately before planting with a heavy coating of these materials. In observing these toxicity tests it soon became apparent that cabbage seedlings developing from such coated seed, while generally uninjured by the treatment, were often markedly less subject to root maggot injury than those from untreated seed. The degree of protection resulting from such a treatment was in many cases so striking that repeated tests bearing on this point have been carried out during the past four or five years in an effort to determine the effectiveness and practicability of this method of applying mercury salts in root maggot control. These tests have been made on various cruciferous crops as well as on several of those subject to attack by the onion maggot and the seed corn maggot, but in the present dis-

[1]Approved by the Director of the New York Experiment Station for publication as Journal Paper No. 33, Jan. 29, 1934.

cussion only those tests having to do with calomel as the insecticide will be considered.

In the preliminary trials referred to the dry seed was at first merely shaken up with an excess of the finely powdered calomel, but as the amount retained by different lots of seed was found to be variable the practice of moistening the seed before applying the calomel was adopted. By this procedure it was found possible to apply a relatively large amount of the powder to the seed and to regulate the quantity that would be retained rather closely by varying the amount of water used in moistening the seed. Some difficulty was experienced at first where water alone was used for moistening the seed with the heavier deposits flaking off and clogging the drill as the seed dried. This condition was finally corrected by the addition of a small amount of some sticker, such as gum arabic, to the water used in moistening the seed. Cabbage seed first moistened with a solution of gum arabic and worked up by hand with an excess of the dry calomel could easily be made to retain from 1½ to 2 pounds of the powdered calomel to each pound of seed with very little loss or clogging of the seeder even after the treated seed had been allowed to dry. When seed is treated with such large amounts of calomel the volume is naturally increased, often practically doubled, and allowance must therefore be made for this and the drill set accordingly. The comparative size of treated and untreated seed is well illustrated in Figure 9 showing two equal lots of onion seed, one treated with calomel at the rate of 2 pounds per pound of seed, the other untreated.

If the seed treatment is to operate at its full efficiency, it is evident that the insecticide must be placed as near the surface of the ground as possible. This means rather shallow seeding and care during cultivation that the soil is not worked up about the base of the plants more than necessary. The rate of seeding should also be as heavy as practicable in order to insure as great a concentration of the insecticide as possible near the point of attack.

The protection following the seed treatment is often surprisingly complete, but is much more pronounced while the seedlings are still comparatively small; in fact at this stage it should be almost perfect. As the plants increase in size, however, with a corresponding enlargement of the stems and perhaps a partial covering of the insecticide to greater depths as a result of cultivation, some late maggot injury almost always develops. For this reason the seed treatment, to be most effective on cabbage seedlings, might well be confined as far as possible to the later planted seedbeds where the peak of egg-laying will come during the period when the plants are still comparatively young.

The seed treatment with calomel or with other mercurials has so far proved of little or no value when applied to such rapidly growing crops as

Fig. 8.—*Above.*—Cabbage seedlings from untreated plot. *Below.*—Cabbage seedlings from plot in which seed was coated with calomel before planting. Groups from left to right represent plants killed by maggot attack, those badly injured, slightly injured and uninjured respectively.

radishes or turnips,—neither does it appear to have any appreciable effect in reducing injury by the seed-corn maggot.

The effect of heavy applications of calomel to the seed in lessening root-maggot injury is illustrated in the case of cabbage seedlings in Figure 8. In the lower half of this plate is shown the cabbage seed-

lings taken from an 8-foot section of row where the seed previous to planting had received an application of calomel at the rate of approximately 2 pounds per pound of seed. The photograph at the top, on the other hand, represents the seedlings taken from a corresponding area of the untreated plot. In each case the plants have been separated into four groups representing in order from right to left the uninjured, slightly injured, and severely injured seedlings; while at the extreme right are those seedlings that were actually found to be dead as a result of maggot injury at the time they were ready for transplanting.

In the calomel treated section out of a total of 187 plants 112 or approximately 60 per cent were uninjured, 63 or 34 per cent were slightly injured and 9 or 5 per cent were severely damaged but still living, while only 3 or 1.5 per cent were killed outright as a result of maggot work. In the corresponding untreated section, on the other hand, out of a total of 210 seedlings only 4 or 1.9 per cent were uninjured, 12 or 5.7 per cent were slightly injured, and 31 or 14.7 per cent severely injured, while 164 or 78 per cent were actually dead at time of transplanting.

It should be noted here that the rate of seeding in this test was rather heavy, also that the protection afforded by the seed treatment, while not perfect by any means, was still great enough to suggest possibilities for this method of application in the production of cruciferous seedlings, particularly in those localities or seasons where the root maggot infestation is not apt to be excessively severe.

This treatment, if it is adopted, must clearly be recognized as a compromise method, however, sacrificing as it does something in the way of efficiency in exchange for a saving in the time and labor ordinarily required where successive applications of the insecticide must be made to the growing plants.

In the case of the onion maggot the particular test chosen to illustrate the effect of such a seed treatment with calomel on the control of this pest is shown in the lower section of Figure 9. Here the two outside rows represented in the photograph as Plats 1 and 2 were planted with seed coated with calomel at the rate of approximately 2 pounds per pound of seed. In addition to the calomel adhering to the seed, Plat 2 received an equal amount drilled in above the seed just before covering. The middle row representing the check received no treatment of any kind. In this test, altho the original rate of seeding was the same in all cases, the plants in the middle untreated row were almost completely destroyed by the maggot, a large part of the injury taking place very early in the season while the plants were still small. Out of the 44 plants remaining in this check row at the time of harvesting, over 30 per cent

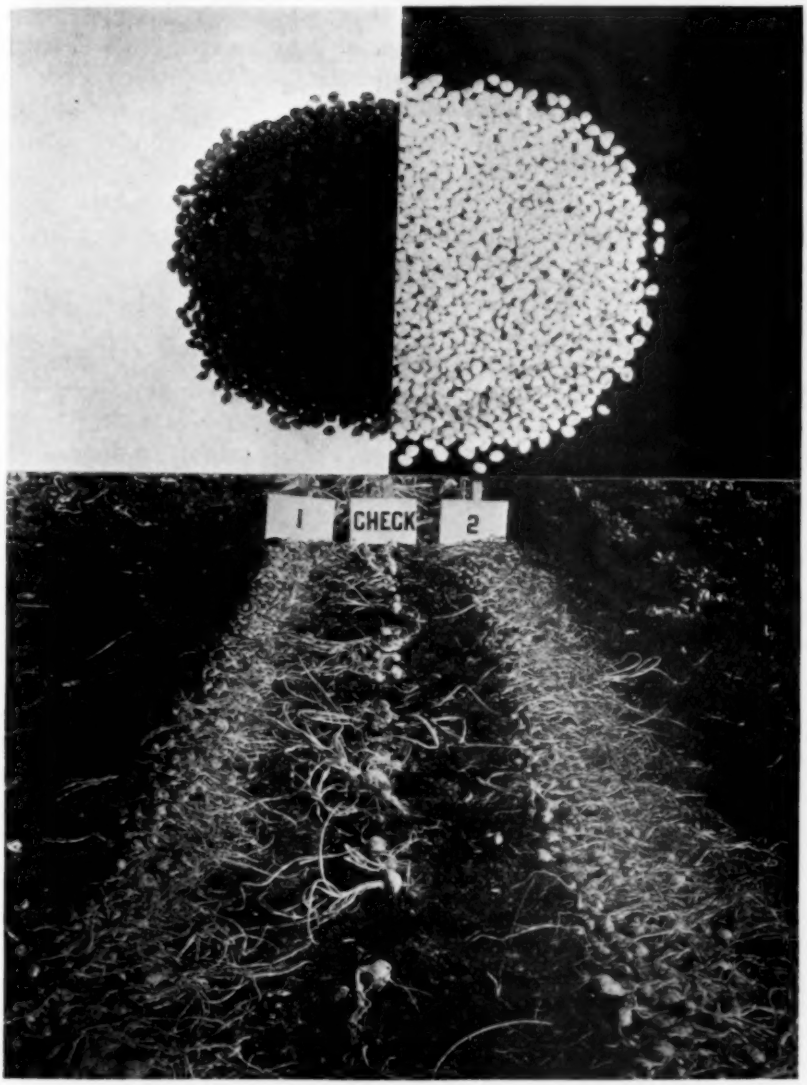


Fig. 9.—*Above.*—Onion seed carrying calomel at rate of two pounds to each pound of seed on right. At left untreated onion seed

Below.—Effect of calomel seed treatment in checking onion maggot. 1, seed treatment only. 2, seed treatment with equal amount drilled in with seed at time of planting. Check, no treatment for maggot control. Seeding at same rate in all three rows.

showed evidence of maggot injury, the total loss in this plat being around 95 per cent. In the case of the treated rows no injury whatever developed in Plat 2 in which the rate of application was doubled, while in Plat 1 where the treatment was confined to the original seed application 10 per cent of the 695 plants harvested showed maggot injury, the total loss from maggot work in this plat being approximately 18 per cent.

It will be noted in the case of both the cabbage seedbed and the onion planting shown in Figures 8 and 9 that the rate of seeding was relatively heavy, being at the rate of approximately 20 to 24 pounds per acre in the case of the cabbage and around 50 pounds per acre in the case of the onions.

Repeated tests have shown that when the regular rate of seeding for onions is carried out the practice of treating the seed with calomel will not insure satisfactory control of the maggot since the concentration of the insecticide does not appear to be sufficiently great. In such cases, while the amount of injury may be very noticeably reduced, the results are seldom consistent enough in the face of a severe outbreak to make this method of practical application. In special cases, however, where a much heavier rate of seeding is the rule, as in the production of set or bunch onions, the seed treatment appears to have a place and has found favor particularly among the growers of bunch onions in some localities even tho the cost may be materially greater than that of other equally effective methods of control. The chief reason given by growers of bunch onions for preferring this method is that its use insures freedom from the injury or discoloration of the green tops that frequently result from the use of other methods of control where successive applications of an insecticide must be made to the growing plants.

EXPERIMENTAL STUDIES ON THE WHEAT WIREWORM, *AGRIOTES MANCUS* SAY

By W. A. Rawlins, *Ithaca, New York*

Losses occasioned by wireworms attacking potatoes constitute a problem of serious proportions to New York State growers. Records of a field survey of potatoes from 256 farms in 13 upstate counties show that 19.7 per cent of all the tubers examined were damaged by wireworms. In many fields practically all the tubers are a total loss. A series of investigations to determine a method of preventing or reducing injuries were initiated in 1930 and some of the results obtained are presented.

The Wheat Wireworm, *A. mancus*, has been reported as a pest of field

crops from the northeastern and north central states and Canada. In Maine, Hawkins ([1] & [2]) finds that the problem is serious in the central farming regions but Aroostock growers are not greatly troubled with wireworms. Thomas[3] reports that this wireworm is a common problem with potato growers in northern Pennsylvania while *Limonius* (*Pheletes*) *agonus* is often troublesome in the truck garden areas in the southeastern part of the state. Although a number of wireworm species are common in New York State, only four have been reported as feeding on potatoes. *Agriotes mancus* Say[4] is most abundant and 90 per cent of the injury is probably caused by this species. Three other wireworms, *Limonius ectypus* (*agonus*) Say, and *Hemicrepidus memnonius* Hbst., and *Melanotus* sp. are minor potato pests although they are not uncommon in most of the potato regions of the state.

Thomas reviewed very thoroughly the voluminous works dealing with wireworm control and found a great difference of opinion and much conflicting evidence. In general the conclusions are that insecticides in the form of seed treatments have not proved effective. Most soil fumigants are influenced by so many soil factors that they cannot always be depended upon to give satisfactory results. The difficulty of application, the toxicity to growing crops, and the expense involved eliminate the more common materials from consideration for wireworm control. Farm practices and crop rotations have apparently offered the most promising means of control and are most practical from the grower's standpoint. Plowing and harrowing in the early fall is said to destroy many pupae, newly emerged beetles and exposes the larvae to predacious enemies. Heavily infested land has been utilized by growing immune crops such as clover, beans and buckwheat. Thorough cultivation during the oviposition period has been recommended to discourage egg laying because the beetles prefer grassy land in which to oviposit. Hawkins finds that rotations which include timothy sod favor infestation by *A. mancus*. Roebuck states that a rapid decrease in the wireworm population resulted from continuous cultivation following the breaking up of grasslands. Observations of experimental workers seem to agree that the sod or grass crop is the source of infestation by *A. mancus*.

Studies have been conducted for the past four years in Wyoming

[1]Hawkins, J. H. Wireworms affecting Maine Agriculture. Maine Agri. Exp. Sta. Bull. 343, 20 pp. 1928.

[2]Hawkins, J. H. Wireworm Control in Maine. Jour. Ec. Ent. vol. 23: 349, 1930.

[3]Thomas, C. A. A review of Research on the Control of Wireworms. Penn. State College. Tech. Bull. 259. 52 pp. 1930.

[4]Determinations of wireworms made by Henry Dietrich, Ithaca, N. Y.

County, New York dealing with the life history and control of the Wheat Wireworm. Under the conditions prevailing in these regions, the eggs were laid during May and June and hatched in about one month. Approximately 45 per cent of the wireworms arising from a single infestation become beetles in three years, an equal number in four years and the remaining larvae transformed to beetles in five years. A single brood took three to five years to fully complete its life cycle. The pupal stage lasted three to four weeks and adults emerged in August but did not leave their earthen cells until the following spring when they made their way to the surface. During the early spring the beetles hid away under stones and clods of earth. When the weather became warm they crawled into cracks of the soil or into the crowns of sod plants and were difficult to find.

In a series of experiments with insecticides and seed treatments conducted in Wyoming County no indications of practical wireworm control were obtained. Dusting the potato seed pieces with arsenicals, mercurials and other poisons did not noticeably reduce the wireworm injury to the seed pieces, plants nor growing tubers. The soil fumigants tested were not effective and in all cases they greatly reduced the stand and retarded the growth of the plants. Several contact insecticides were tested and poisons such as arsenicals were used but none of these materials appreciably reduced the numbers of wireworms.

Since most of the literature regarding wireworm control through farm practices refers to observations rather than experimental data, it was thought advisable to obtain further information in regard to the place of rotations in wireworm infestations and control. Sampling for wireworm populations was done during August and September. Samples taken in 1932 were three square feet in area and those taken in 1933 were four square feet. The soil was removed to a depth of 6 to 8 inches, and sifted through four screens of different sizes. Two screens, one of five meshes and another of 14 meshes to the inch, screened out all stones and debris. The beetles and large larvae were retained in the second screen. Two other screens, having 16 and 20 meshes to the inch respectively, were used to obtain the small wireworms. Numerous examinations of the final siftings did not show any young larvae escaping as a result of this method. In sod young wireworms were not found at depths greater than 6 inches and a majority were not below 3 inches. The depth of the samples in cultivated areas were 8 inches as it was thought that in loose soil the young larvae might migrate downward and not be found in shallow samplings. The samples were so taken as to be representative of the population in the plots.

Field studies show a very definite relation between rotations and abundance of wireworms. The common cropping system in this region includes three crops namely: grain followed by a sod of clover and timothy which in turn is followed by potatoes. Each crop occupies the land once every three years. In the dairy regions sod may be left for two successive seasons thus lengthening the rotation to four years. Although sod is a part of the ordinary cropping system many potato seed growers having large acreages dispense with hay except where it is used as a green manure. The first year larvae appeared almost exclusively in sod (Table 1). Apparently the beetles prefer grasslands for oviposition.

TABLE 1. THE RELATION OF THE COMMON ROTATION SYSTEMS IN WYOMING COUNTY TO WIREWORM POPULATION AND SIZE OF THE WIREWORMS

Year	Crop	Population	Beetles	Stage and number of individuals		
				Mature larvae	Second year larvae	First year larvae
1930.....	Sod					
1931–33.....	Potatoes	22	18	4	0	0
1931.....	Sod					
1932–33.....	Potatoes	308	43	222	43	0
1930.....	Sod					
1931.....	Potatoes					
1932.....	Grain					
1933.....	Sod	465	43	59	14	349
1930.....	Potatoes					
1931.....	Grain					
1932.....	Sod					
1933.....	Potatoes	1025	22	625	371	7
1930.....	Grain					
1931.....	Sod					
1932.....	Potatoes					
1933.....	Grain	733	233	437	63	0
1930.....	Potatoes					
1931.....	Grain					
1932.....	Sod					
1933.....	Sod	542	9	26	245	262

Comparatively few young larvae were found in the potato crop or the grain crop which followed. There is a decided variation in the rate of maturity in all the populations so far studied. An average of 60 per cent of the larvae was mature or nearly mature by the end of the second year. By the end of the third year 39 per cent of the population appeared as beetles while the remaining larvae were full grown. Thus a rotation that provides a sod crop every third or fourth year is admirably suited to continuous reinfestation.

A series of experimental plots were set up in which comparisons were made of the first year larval populations in sod and cultivated land.

Infestations of *A. mancus* are confined to several areas in a field, usually the low lying spots, although the knolls may sometimes be infested. The plots were laid out in the first year sod fields on the areas where wireworms had previously been abundant and where beetles were known to be present. Plats of sod were plowed and harrowed before oviposition started and similar strips of sod were left as checks. All of these plats extended thru a number of wireworm areas. The cultivated strips were planted to either potatoes or grain, or summer fallowed.

Results of these studies are presented in Table 2. The cultivated plats were not reinfested by *A. mancus* but the sod had large popu-

TABLE 2. THE EFFECTS OF SOD CROPS COMPARED WITH CULTIVATED LAND ON THE ABUNDANCE OF WIREWORMS

Field	Crop	Number of replications	Number of samples	Number of first year larvae	Population per acre
1	Sod	4	29	139	52,272
	Cultivated	4	29	1	327
2	Sod	3	18	65	39,204
	Cultivated	3	18	0	0
3	Sod	4	20	109	60,984
	Cultivated	4	20	3	1,612
4	Sod	2	20	182	100,188
	Cultivated	2	20	2	1,089
5	Sod	2	26	91	50,529
	Cultivated	2	13	0	0
6	Sod	2	12	234	284,447
	Cultivated	2	8	14	25,700
Total 6	Sod	17	125	820	97,937
	Cultivated	17	108	20	4,621

lations in all cases. An unusually high number of first year wireworms appeared in the cultivated plot of field 6. The sod in this field was plowed after oviposition had started and it is probable that beetles laid some eggs before the land was cultivated. From the sod portions of the experimental plots 125 samples yielded 820 young larvae while 108 samples in parallel cultivated strips yielded only 20 young larvae. If placed on an acre basis the average of the populations found in the sod is 97,937 wireworms as compared to an average of 4,621 wireworms on the cultivated land.

It was possible however that these plots did not give a true picture of what would occur under average field conditions. In large cultivated fields not near grass lands the beetles might oviposit regardless of the soil covering. There is no good evidence that *A. mancus* adults migrate from field to field nor that they fly long distances. A number of fields heavily infested with wireworms were cultivated continuously. Three of these fields have been sampled for larval populations each year since the

original sod crop was plowed under. The samples were taken in the same wireworm areas each year.

It will be noted from Table 3 that beetles emerged from fields during the spring of the second year following the sod. Reinfestation did not occur in the three fields which were continuously in cultivation. Contrasting this condition with the field which included a new sod crop at the end of the three year rotation cycle, there is an apparent heavy reinfestation as measured by the population of first year larvae.

TABLE 3. CULTIVATION OF LARGE INFESTED AREAS AS AFFECTING REINFESTATION OF THOSE AREAS

Year	Crop	Number of samples	Wireworm population		
			Beetles	Mature and second year larvae	First year larvae
1930.....	Sod				
1931.....	Potatoes	13	1	88	0
1932.....	Potatoes	13	42	23	0
1933.....	Potatoes	39	36	18	1
1930.....	Sod				
1931.....	Potatoes				
1932.....	Potatoes				
1933.....	Grain	17	7	4	0
1929.....	Sod				
1930.....	Potatoes	13	1	119	0
1931.....	Potatoes	13	19	83	0
1932.....	Grain	13	10	17	0
1933.....	Grain	20	0	3	0
1929.....	Sod				
1930.....	Potatoes	13	1	102	0
1931.....	Grain	26	33	41	0
1932.....	Sod	23	6	8	107

To further test the effects of eliminating sod fields on both wireworm populations and the resulting injuries to potato tubers records were taken in additional fields. The results are presented in Tables, 4 and 5.

TABLE 4. DECREASES IN WIREWORM POPULATION AS A RESULT OF CONTINUOUS CULTIVATION

Field	Year samples were taken	Number of samples	Total population	Total beetles	Total larvae
1.....	1931	13	90	1	89
	1932	13	65	42	23
	1933	13	18	12	6
2.....	1932	13	121	0	121
	1933	13	121	33	88

It seems fairly clear that the elimination of the sod crops from the crop rotations reduces wireworm populations consistently and at a surprisingly fast rate. Moreover wire-worm injury to potato tubers decreased so as to be negligible after three years of cultivated crops. The proportion of tubers injured in the second crop of potatoes was much less than in the preceding crop.

TABLE 5. THE TREND OF WIREWORM INJURY TO POTATO TUBERS FOLLOWING ELIMINATION OF SOD

Field	Year	Crop	Per cent injury to potato tubers
1	1929	Sod	
	1930	Potatoes	92.0
	1931	Potatoes	17.7
	1932	Grain	———
	1933	Potatoes	.035
2	1930	Sod	
	1931	Potatoes	85.0
	1932	Potatoes	4.0
	1933	Potatoes	.75

The question has been frequently raised as to the effect on wireworm infestations of continuing hay crops over a period of years. The larval populations of four fields in sod for two consecutive years have been obtained by sampling. From the results in Table 6 it appears that the number of wireworm larvae were nearly doubled where sod crops were grown for two years in succession. While this exact proportion may not hold in all circumstances it seems apparent that an increase in wireworm population occurs where fields are left in sod for two years.

TABLE 6. INCIDENCE OF INFESTATION OF FIELDS IN SOD FOR TWO CONSECUTIVE YEARS AS MEASURED BY FIRST YEAR LARVAE

Field number	Total number samples	Number of larvae found in first year sod	Number of larvae found in second year sod
1	6	57	87
2	8	153	46
3	20	58	81
4	10	92	89
Totals 4	44	360	303

SUMMARY.—Experiments to determine control measures for the wheat wireworm, *A. mancus*, indicate that the most satisfactory solution may be attained thru adoption of suitable crop rotations. Where potatoes are injured by wheat wireworms it is advisable to eliminate the sod crops from the rotation. The data presented prove several practical points of interest.

1. Infestations of wheat wireworms start in fields planted to hay or sod.

2. Wireworms will increase in numbers if land is left in sod for two consecutive years.

3. All the wireworms from a single infestation do not mature and emerge as beetles in three years.

4. Beetles will occur in large numbers even in cultivated fields the second and third years following a sod and a few will emerge in the fourth year.

5. Marked decreases in larval populations and resultant injury to potato tubers will result from continued cultivation of infested fields.

DUTCH ELM DISEASE CONTROL AND THE ELM BARK BORER

By E. P. FELT, *Bartlett Tree Research Laboratories, Stamford, Conn.*

The Dutch elm disease, *Graphium ulmi* Schwarz, now generally established in the metropolitan area of New York and with a bad European record, is a real threat to the well being of all species of elms in the United States. It does not follow that the elms will be swept out of existence in somewhat the same way as the chestnut trees were destroyed by chestnut blight. The two diseases are different, and the conditions under which the host trees are growing are also different. Both of these factors must be taken into consideration in attempting to forecast the probable effect of this disease upon the elms.

The recognition of the European elm bark beetle, *Scolytus multistriatus* Marsh, as an important and possibly the principal carrier of the Dutch elm disease places the economic status of this bark borer in a new light and makes information in regard to the beetle and its habits of great importance. There are good reasons for believing that the most effective method of controlling or eradicating the Dutch elm disease is by controlling the carrier. It is a well known principle in medicine that control of the carrier means control of the disease, and the same is true in the realm of plant disease or pathology. The developments of the past summer have brought to light some facts in regard to the European elm bark borer which deserve most careful study, in view of their bearing upon the possibilities of controlling this insect and through it, the Dutch elm disease.

The elm bark borer was abundant and supposedly very injurious to the elms of Cambridge, Mass., in 1909 and for some years following, and as a result a somewhat careful study was made of the insect by Dr. J. W. Chapman. He states that the longest galleries sometimes contain as many as 140 eggs, though usually there are not more than 80. He found that oviposition continued for several weeks and that consequently a gallery might contain both eggs and partly developed larvae. The first brood in eastern New England deposits eggs the last of May and in June, and there is a second major egg-laying period the last of August and early in September. The grubs of this last brood winter in the inner bark and complete their development during the first warm days of spring. The pupal cells are located in the outer bark just under the surface. Dr. M. W. Blackman, in a manifold distributed October 24, 1933, states that observations indicate that some of the beetles are in flight at all times during the warm months. It is probable that the breeding habits are at least similar to those of the better known fruit tree bark

beetle, *Scolytus rugulosus* Ratz., with its two somewhat well marked periods of greatest activity, namely in the early spring and late summer or early fall, and an occasional development of small to larger numbers when conditions are favorable during the intervening months. Observations of the past season have shown that the elm bark beetles feed on the buds, in the crotches of the smaller branches, and that it is this habit which may result in the dissemination of the Dutch elm disease by insects issuing from infected trees. The conditions in the area where this disease is somewhat prevalent indicate a close relation between abundance of the beetle and prevalence of the disease.

It is obvious from the above that the abundance of trees suitable for the breeding of this beetle and the flight habits of the insect have important bearings upon the possibility of controlling or eradicating the Dutch elm disease. It should be noted first that this disease starts in the small branches and produces a progressive dying of the wood, and if there be a general infection, the speedy death of the tree may result. The beetle is not only a carrier of the disease, but finds in the sickly and dying wood produced by the fungus admirable conditions for breeding in enormous numbers. Briefly, there is a vicious circle, the beetles carry the infection which kills twigs, branches and trees and thus make possible in turn an enormous multiplication of the insect carrier. One helps the other. The possibilities in this direction are indicated by the fact that six square inches of bark may produce 28 beetles, and using this as a basis, it was estimated that a large elm with a trunk diameter of three feet, nine inches might, under favorable conditions, produce a million and a half beetles. The significance of these figures is readily grasped when it is remembered that were such a tree infected with the Dutch elm disease, the beetles issuing therefrom would very likely carry the trouble to many other elms. This is apparently what occurs, and the somewhat general, though scattered prevalence of the disease in northern New Jersey, where the elm bark beetle is common, suggests that such is actually the case.

In this connection it may be well to state that Federal agents have secured data which go far to establish imported Carpathian or burl elm logs infected by the disease and infested by *Scolytus multistriatus* Marsh as the probable means by which the disease became established in this country. The principal area showing this infection centers around the Port of New York, one tree being found at Baltimore, Md. Infected logs have also been located at Norfolk, Va., and New Orleans, La. All known infected trees in America are near enough to the above ports of entry or to railroad lines over which imported elm logs have been shipped

to afford strong support to this belief. It should also be stated that so far as known the larger elm bark borer, *Scolytus scolytus* Fabr., although also found in imported elm logs, has not become established in America. It is considered in Europe as a more vigorous and dangerous species.

The production of enormous numbers of bark beetles by diseased elms is not the only important factor. Their manner of flight and the distances covered are also significant. Several cases which throw light upon this have come under observation in the last few years. A large limb of an English elm at Princeton, N. J., was found badly infested with the beetles in March, 1930. It was brought to notice through woodpeckers chipping off the outer bark in order to get at the grubs. The entire infested limb was removed and burned. Observations in that section the following summer and the year after disclosed no further evidence of infestation. A similar tree was found in a Stamford, Conn., park in December, 1932, and here likewise the infestation was so general that a considerable proportion of the outer bark of a number of limbs had been flaked off by woodpeckers. This tree was removed and burned during the winter, and no subsequent infestation developed in that immediate vicinity. Both of these trees were probably attacked by many of the bark beetles. It is evident that these infestations were decidedly local. In August, 1933, our attention was called to a recently transplanted elm on Long Island, which was being invaded by hundreds of the beetles. There was an opportunity of examining elms in that vicinity, and nowhere were there indications of extensive breeding in adjacent trees. These three cases suggest, and we believe this will be borne out by later observations, that the European elm bark beetles fly in swarms when conditions are favorable, and concentrate upon weakened trees or parts of trees. It happens, in the case of the Stamford tree above mentioned, that it was located in a conspicuous place where an observant park superintendent would have quickly noticed if anything had been wrong the preceding season, aside possibly from a somewhat generally lowered vitality, this latter being probable, owing to recent street improvements.

There is another factor of great importance, and that is the distance and direction of this flight. The past season scattered elms in southern Westchester County, N. Y., one in southwestern New England and a number on western Long Island were found infected by the Dutch elm disease, and the judgment of the pathologists is that all these infections occurred during the summer of 1933. It is known that older infected elms were found on Staten Island and in northern New Jersey, and consequently if this opinion is correct, which is probably the case, beetles

carrying the disease must have flown, presumably in numbers, 20 to 25 miles. This distance does not necessarily represent the maximum for these insects. Since the affected elms in this recently infected area are widely scattered, there is a presumption that the disease-carrying beetles flew in swarms and settled on one or more widely separated trees. Both of these factors are important. One gives an idea of the distance the infection may be carried in one season, and the other indicates the possibility of locating and dealing with these newly infected trees before the following generation of beetles matures and escapes to carry the disease to other trees. Incidentally, it is well to remember that we find this habit of flight and concentration on favored trees or groups of trees not only in the related fruit tree bark beetle, *Scolytus rugulosus* Ratz., mentioned above, but also in the more aggressive hickory bark beetle, *Scolytus quadrispinosus* Say. Furthermore, it should be borne in mind that similar habits have been noted for a number of other bark beetles, notably several species of Dendroctonus, with the movement of swarms over considerable distances and concentrated attack upon individual trees or groups of trees. It is well to keep in mind that the prevailing westerly, especially southwesterly winds, are favorable to a speedy easterly or northeasterly movement of infected elm bark beetles. In other words, the presence of the Dutch elm disease in the metropolitan area of greater New York actually threatens the elms of New England, since prevailing winds are likely to facilitate beetle movement in an easterly or northeasterly direction.

There is another factor worthy of emphasis, and that is the obvious limitation of the elm bark beetle, practically speaking, to sickly or dying wood. Cases have been noted in the Dutch elm disease infected area of beetles invading healthy or apparently healthy trees, depositing eggs and then either the eggs or the grubs failed to mature. This development has also been noted in the case of the hickory bark beetle. It follows that the systematic cutting and burning of sickly and dying trees is a practical method of controlling the beetle, not only in areas where the Dutch elm disease occurs, but in other sections. In view of the fact that this disease may be found in new and possibly distant localities, it is believed wise to recommend the general removal and burning of sickly or dying elms or parts of elms—*tree sanitation*—for sections from southern New Jersey to southern Maine and extending back from the coast 100 to 250 miles or more. This is approximately the area where this bark beetle is known to occur. If this were done prior to the finding of the Dutch elm disease, this would be an area where the opportunities for further dissemination were greatly reduced, and the chances of actual

eradication, which appears to have been accomplished in Ohio, falls within possibilities.

It is our judgment that although the Dutch elm disease is a pathological trouble and the actual agent in killing elms, the effective control of this disease is through the control of the principal carrier, the European elm bark beetle. This is primarily an entomological problem which will be solved largely by reducing to a practical minimum the elm borer population, especially that of the European elm borer.

It is comparatively easy for entomologists to agree with the above. They may not so readily accept a statement to the effect that control of the European elm bark beetle may be greatly enhanced by a spraying program designed especially to control destructive leaf feeders, particularly canker worms, the elm leaf beetle and the Japanese beetle, although, since the European elm bark beetles feed on the smaller twigs and branches, there is a probability that some of these borers would be destroyed by the poison adhering to the parts they attack. This latter is probably a minor and incidental benefit. The important point in connection with a spray program is that it keeps the trees in a relatively good condition by protecting the foliage and in that way prevents, in large measure, the development of sickly and dying wood. We believe the recommendation is entirely sound and spraying really better than to allow repeated defoliations and resort to the somewhat unsatisfactory method of annually removing sickly and dying wood.

There is, in addition, the problem of the weak tree. In earlier years this has not been considered of particular importance. Under present conditions such trees may become prolific breeding places for the elm bark beetle and potential aids to the spread of the Dutch elm disease. Such trees should either be removed if they are of no particular value, or else restored to health by judicious pruning and feeding, particularly the latter. There is no place for the weak tree in sections where the Dutch elm disease is likely to appear.

It may be added that effective handling of this menacing situation is dependent in large degree on prompt, coordinated action throughout the area where the Dutch elm disease is known to occur or is likely to be found within a year or two. Independent work by states or small political units would at best prove relatively inefficient. The most effective work will be done before warm weather of next spring attracts the beetles from their winter quarters.

EXPLORING THE UPPER AIR FOR WIND-BORNE GIPSY MOTH LARVAE

By C. W. COLLINS and W. L. BAKER, *Bureau of Entomology, U. S. Department of Agriculture, Melrose Highlands, Mass.*

In 1910 experiments were initiated at the Melrose Highlands, Mass., laboratory of the Bureau of Entomology, U. S. Department of Agriculture, to determine to what extent gipsy moth (*Porthetria dispar*) larvae were borne by the wind, so that control methods could be devised and put into practice that would most effectively prevent spread. These studies were begun by A. F. Burgess[1] who released newly hatched first instar larvae that had spun silk in front of an electric fan. The observation that larvae drifted from 20 to 30 feet in the laboratory laid the foundation for larger field experiments. The senior writer,[2-3] continued the investigations in 1913–1916. By means of large wire screens of ⅝″ and ¾″ mesh (later, 1/6″ mesh being used) covered with a sticky substance he caught larvae that had drifted from the mainland to Isles of Shoals, off the coast of New Hampshire, at distances of 6 and 13½ miles. Further distance was recorded with catches made at Provincetown, Mass., where the source of infestation was across Cape Cod Bay, at distances of 19 to 30 miles. Altitude records were secured by placing a screen on a standpipe in Merrimac, Mass., in 1914. The screen was 55 feet above the summit of the hill. During the season 141 larvae were caught on the screen. Similar records, but of higher altitude, were secured on a small mountain in Hooksett, N. H., in 1919. Here the tower extended 65 feet above the rocky summit of the "Pinnacle." A total of 347 larvae were taken on the screens exposed, a large proportion of which were caught on horizontal cloth screens near the top of the tower. The latter catches clearly demonstrated that newly hatched larvae are borne by wind to considerable heights and that they must finally settle more or less evenly over the surrounding country.

The data accumulated point to the importance of wind as being the chief agency of spread. Dispersion has also been found to be more prevalent at the time warm surface winds are coming from the west. Dispersion records indicate that during a 40-year period the insect

[1]Burgess, A. F. The Dispersion of the Gipsy Moth. U. S. Dept. Agr., Bur. Ent. Bull. 119, 62 p. 1913.

[2]Collins, C. W. Dispersion of Gipsy Moth Larvae by the Wind. U. S. Dept. Agr. Bull. 273, 23 p. 1915.

[3]Collins, C. W. Methods Used in Determining Wind Dispersion of the Gipsy Moth and Some Other Insects. Jour. Econ. Ent., Vol. 10, p. 170–176. 1917.

spread from two to two and one half times as rapidly towards the northeast and southeast as it did towards the northwest and southwest, owing to the prevailing westerly winds. Until recent years the gipsy moth has been confined mainly to New England. If it had become established at the same time in the Central States or Middle Atlantic States both these sections, and probably New England as well, would have become generally infested in equal or less time.

In order to go further towards solving this problem, cooperative arrangements were made with the meteorological department of the Massachusetts Institute of Technology for altitude flights in 1932 and 1933 over a section of southeastern Massachusetts that was heavily infested with the gipsy moth. The plane was provided and most of the expenses were borne by the Institute. Cooperation with Prof. C. G. A. Rossby, Dr. K. O. Lange and the pilots was most cordial.

To carry on the airplane experiments successfully it was necessary to use a trap composed of wire screens covered with a sticky substance that would be effective at low temperatures. The aim was to filter as much air as possible in a comparatively short time and to have the screens so constructed that they offered little resistance to the speed of the plane. It was also necessary that the screens be well covered or protected, when not exposed, to avoid picking up insects while the plane was ascending or descending.

Results of Experiments in 1932.—Eggs of the gipsy moth began hatching at Melrose, Mass., on May 2. This date (based on observations over a period of many years) was normal for hatching. Calculating from this date, as in previous years, it was believed that maximum hatching should take place during the period of May 10 to May 20. Arrangements were thus made to begin flying operations on May 10 and to continue them daily, dependent upon favorable weather conditions, through May 20. It was thought inadvisable to make flights on days when ground temperatures ranged below 70° F. A host of field observations indicate that newly hatched larvae are practically inactive below 60° F., and only slightly active from 60° to 70° F. Above 70° F. they become more active and are most active around 80° to 85° F.

The tests of 1932 were made by using a special insect trap, devised by Coad and assistants,[4] with certain modifications. These modifications were not engineered with the idea of improving the efficiency of the trap, but were necessary modifications due to the structural characteristics of the plane then in use by the Massachusetts Institute of Technology

[4]Coad, B. R. Insects Captured by Airplane are Found at Surprising Heights. U. S. Dept. Agr. Yearbook of Agriculture, 1931, p. 320.

TABLE 1. SPECIMENS COLLECTED DURING FLIGHTS MADE FOR TRAPPING WIND-BORNE GIPSY MOTH LARVAE IN THE UPPER AIR
Season of 1932—May 10 to May 21, inclusive

Altitude in feet	Diptera	Coleoptera	Hymenoptera	Lepidoptera	Hemiptera	Homoptera	Arachnida
300–500	Bibionidae (1)[1]	Heloidae (1)		Porthetria dispar (1)			(2)
300–500	Megaselia sp. (1)						
300–500	Lonchoptera lutea (1)						
350–500	Ephydridae (1)						
350–500	Tipulidae (1)						
500	Ephydridae (2)	Cytilus alternatus (1)					
500		Bembidion sp. (1)					
500		Laemophloeus biguttatus (1)					
600–120							(1)
700–900	Sciaridae (1)						
1000	Phoridae (1)		Hoplogryon sp. (1)	P. dispar (2)			
1000			Harmolita sp. (1)				
1500	Sciaridae (1)		Aphidius nigripes (1)				
1500	Ephydridae (2)						
2000	Chloropidae (1)						
?					Ischnorhynchus resedae (1)	Aphalara sp. (1)	

[1]Figures in parentheses indicate the number of specimens of each group taken at any altitude.

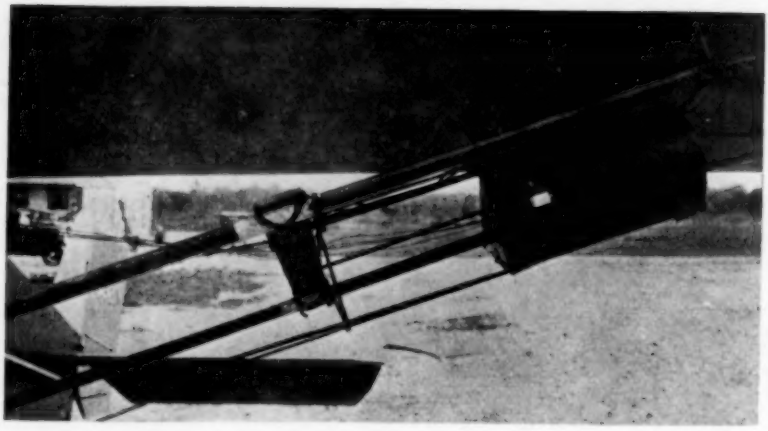
TABLE 2. SPECIMENS COLLECTED DURING FLIGHTS MADE FOR TRAPPING WIND-BORNE GIPSY MOTH LARVAE IN THE UPPER AIR
Season of 1933—May 10 to May 23, inclusive

Altitude in feet	Diptera	Coleoptera	Hymenoptera	Lepidoptera	Hemiptera	Homoptera	Arachnida
500	Oscinella frit (3)	Staphylinidae (1)	Gastrancistrus sp. (1)				
500	Chironomidae (2)						
500	Empididae (1)						
500	Mycetophilidae (1)						
1,000	Megaselia sp. (2)	Aphodius sp. (1)				Psyllidae (1)	(1)
1,000	Bibio sp. (1)						
1,000	Oscinella frit (2)						
1,000	Mycetophilidae (1)						
1,000	Borboridae (1)						
1,000	Chironomidae (1)						
1,500	Oecothea fenestralis (1)						
1,500	Oscinella frit (1)						
2,000	Lonchoptera sp. (1)	Tachistodes paritarius (1)		Porthetria dispar (1)			
2,000	Oscinella frit (1)						
?					Antillocoris pallidus (1)		
500	One specimen impossible of identification.						

[1]Figures in parentheses indicate the number of specimens of each group taken at any altitude.

Plate 5

A



B

C

(Plate 5A). Only one trap could be used because of the presence of a meteorograph under one wing. By removing one closed compartment from the original trap it was possible to attach the trap vertically to the wing proper. Owing to the absence of supporting struts on this plane, this type of mounting was necessary. Later in the season it was necessary to remove the trap from this plane and place it on one carrying supporting struts. This was easily accomplished (plate 5, B). Furthermore, these modifications lessened somewhat the resistance of the trap to the forward progress of the plane. This was important because the presence of a trap on only one wing tended to pull the plane to one side in flight. The trap screens were treated with a sticky substance composed of a mixture of melted powdered rosin and castor oil.

The results of the experiments of 1932, considering the weather conditions, were very gratifying. From Table 1 it will be noted that three newly hatched gipsy moth larvae were taken; one at an elevation between 300 and 500 feet and two at 1,000 feet above sea level. As was to be expected, many other forms of insect life were taken at various altitudes. During 1932 only nine flights and forty screen exposures were made. The altitudes of the exposures ranged from 300 to 5,000 feet; the average altitude approximated 1,200 feet and the average exposure time per screen was 12 minutes and 11 seconds. Weather conditions during this season were, on the whole, very unfavorable for maximum larval activity. In fact only nine exposures for a total of 90 minutes were made over heavily infested territory when ground temperatures were high enough for noticeable larval activity. Table 1 gives a list of the insect specimens taken during this season.

Results of Experiments in 1933.—During the season of 1933 a different type of insect trap was used. This trap was designed by Dr. Karl O. Lange of the Massachusetts Institute of Technology, and should properly be called the Lange insect trap. A. E. Lantz, of the Bureau of Entomology Laboratory, Melrose Highlands, Mass., performed valuable services in its construction. The idea responsible for the development of this new trap was two-fold in nature. First, it was desired to increase as much as possible the exposed surface of the trap to the on rushing air; and, second, to so construct the trap that the possible

A. Modified Glick insect trap mounted vertically to wing of Cessna monoplane. (Courtesy Dr. K. O. Lange.)

B. Same insect trap as A—mounted on supporting struts of Curtiss-Robin monoplane.

C. Lange insect trap mounted horizontally on Curtiss-Robin monoplane. Note exposed screen in middle of parallel braces—other screens collapsed.

danger of the formation of a dead air space immediately in front of the treated screens should be greatly minimized, or eliminated.

In attempting to fulfil these requirements Dr. Lange designed a trap of six collapsible screens to be mounted underneath the wing on horizontal bars of airplane tubing, 1 inch in diameter. The screens were manipulated by the pilot in the cockpit by means of wires running from the cockpit to the screens through the forward supporting tube. Each screen was constructed in the form of a hollow pyramid, the sides of which were composed of 40 mesh copper screening. The screens were made collapsible by mounting them on piano hinges. The mouth, or base, of each pyramid-like screen had an area of 2 square feet—twice the area of the screens composing the trap used by Coad. The surface area of the screened sides was 5.3 square feet, thus giving a ratio of filtering surface to exposed surface of 2.65 to 1. Therefore both purposes mentioned above were fulfilled. First, by constructing a trap with six screens instead of five and enlarging the exposed surface of each screen from 1 to 2 square feet, the amount of air sampled per unit of time was doubled. Second, by constructing the screens "funnel-like" (hollow-pyramid), and increasing the filtering surface more than five times, the danger of a dead air space was more or less eliminated. Furthermore, the pilots reported that the resistance offered by this trap was of no greater importance than the resistance offered by the smaller trap used by Coad. For details concerning mounting and general appearance of the Lange trap, see Plate 5, C.

The results obtained in 1933 might be considered less satisfactory than the results of 1932 on the basis of capture of gipsy moth larvae, but when it is noted that the one taken in 1933 was from an altitude of 2,000 feet, one is constrained to believe otherwise. Furthermore, the capture of a single specimen at such an altitude leads one to believe that there must have been great numbers floating above the forest crown for at least 2,000 feet above sea level, otherwise the capture of a single specimen should have been extremely improbable. During the 1933 season weather conditions were far from favorable for maximum dispersion; although the season was probably more favorable than the 1932 season, if one considers temperature alone. During 1933 a total of 14 flights and 62 exposures were made, beginning May 10 and ending May 23. The altitudes of the exposures ranged from 500 to 3,000 feet and averaged approximately 1,250 feet above sea level, and the average exposure time per screen was 11 minutes and 27 seconds. During this season exposures were made over a region slightly northeast of the region selected in 1932. This was necessitated by a shift in intensity of gipsy

moth infestation in that direction. For a list of the specimens taken in 1933, see Table 2.

All insect material, excepting the gipsy moth larvae, taken during the two seasons was identified by specialists of the Bureau of Entomology in Washington; the gipsy moth larvae being identified by the writers themselves.

Summarizing, it is noted that only four first instar gipsy moth larvae were taken during the two seasons of flight; one at an altitude between 300 and 500 feet and two at 1,000 feet in 1932, and one at 2,000 feet above sea level in 1933. To realize that those records were satisfactory, it is necessary to consider the incredibly minute size of any individual sample. The volume of a cubic mile of air is stupendous, and there were many cubic miles of air immediately above the heavily infested forests over which the plane was flown. Calculating from the size of the screen used in 1933, it would require more than 25 years of continuous flight and exposure to filter the air in 1 cubic mile. Further, it is seen that only one part in 125,000 of the air above one acre to a height of 2,000 feet was sampled by the trap when the larva was taken at that altitude. Thus it is to be observed that the chance of capturing a larva on a screen such as used in these flights was unbelievably small unless, as was probably the case, a multitude of larvae were afloat above the forest crown at the time.

NOTES ON THE BEECH SCALE, *CRYPTOCOCCUS FAGI* (BAER.) DOUGL., IN NEW ENGLAND

By R. C. Brown, *Bureau of Entomology, U. S. Department of Agriculture, Melrose Highlands, Mass.*

The beech scale was first discovered in the United States in November 1929, in the Arnold Arboretum, Boston, Mass. (*2*).[1] Hewitt (*4*) had reported its discovery in Nova Scotia in 1911, and an inquiry made at that time indicated that it had been there for a number of years. It is likely that it came to North American from Europe, where it causes considerable damage to the European beech, *Fagus sylvatica* L. (*5*). In North America it attacks the American beech, *Fagus grandifolia* Ehrhart, and the imported *Fagus sylvatica*.

The beech scale claimed the attention of the Melrose Highlands, Mass., laboratory, Bureau of Entomology, in the spring of 1931. (*1*). As conditions permitted, members of the laboratory force scouted most

[1]Italic numbers in parentheses refer to Literature cited at the close of the article.

of the towns in Massachusetts, Rhode Island, Connecticut, and the southern halves of New Hampshire and Maine. The Maine Forest Service, the New Hampshire State Entomologist's Office, and the Massachusetts Department of Conservation have cooperated in this work. Towns within a radius of 20 miles of Boston and along the "North Shore" to Gloucester, Mass., as well as a group of towns in southeastern New Hampshire and southern Maine, have been rather thoroughly scouted, but except in this relatively small area the scouting was very superficial, only the beech stands adjoining the main highways being inspected. The Maine Forest Service has quite thoroughly examined beech stands in towns near Liberty, Me.

As a result of this work in New England the beech scale has been found in five areas (Fig. 10), as follows: Washington County and about Liberty in Maine; a group of towns in southern Maine and adjoining towns in New Hampshire; in Gloucester, Mass., and nearby towns; and an area comprising several towns in metropolitan Boston. The largest and most severely infested area is that in Washington County, Maine. The present known distribution (Fig. 10) indicates that further intensive scouting may reveal a continuous infestation from Boston to New Brunswick.

LIFE HISTORY.—The life history of this insect in the United States has not as yet been worked out in detail. In the vicinity of Boston, egg deposition begins about June 15 and reaches a maximum in July. Hatching begins about August 1st and continues into September. Crawlers (Fig. 11, D) are therefore most abundant in August and September. It is while in this stage that the species distributes itself over the bark. When a desirable spot is found, such as under the woolly covering previously formed by the scale, under lichens, or in depressions or fissures, the crawler attaches itself by inserting its beak into the bark. From the time the crawler becomes quiescent, the secreting of the white woolly wax begins and continues throughout its life. The scale overwinters in this stage, and beginning in May it transforms to the preadult. About 15 days later it becomes mature. Mature females (Fig. 11, A) are nearly circular and are from 0.5 to 0.8 mm. in diameter. Eggs are deposited in the woolly covering. There is, therefore, one generation annually. Reproduction is, apparently, entirely parthenogenetic, males of the species being unknown.

Distribution from tree to tree is accomplished largely by the wind, eggs and larvae being borne in clumps of dislodged wool. Birds and squirrels may also aid in the dispersion of this species.

A light infestation of the beech scale appears on the bark as minute

FIG. 10.—Map showing towns in New England infested by the beech scale. November 1933.

white dots which may be isolated or form thin vertical lines. As the infestation increases the dots increase in size and become more numerous until finally the trunk of the tree and the lower side of branches may be completely covered with a white mass. (Fig. 12.) The scale attacks the trunk, branches, and exposed roots of beeches of all ages.

NATURAL ENEMIES.—In New England natural enemies of the beech scale do not appear to exert a strong controlling influence. Only one predator that gives any promise of becoming effective has been found generally throughout the infested area. This is a native coccinellid,

FIG. 11.—The Beech Scale; *A*, Mature female. (f. antenna; a. ocellus; g. opening to reproductive organs; st. 1 and st. 2. thoracic spiracles; *B*, Rudimentary antenna; *C*, Region around opening to reproductive organs, showing hairs and wax pores; *D*, Crawler (1st larval stage); *E*, Lateral view of 2nd larval stage. (Hibernating form.) From Nitsche. (All greatly enlarged.)

Chilocorus bivulnerus Muls., which, in its larval and adult stages, feeds on the scale. Adults of a lampyrid, *Lucidota* (*Ellychina*) *corrusca* L., were found in eastern Maine to be more abundant where the beech scale was present than in uninfested areas. Larvae of this species may be found, by further investigation, to feed on the scale.

An attempt was made during the past season to recover internal parasites. For this purpose paraffined pasteboard boxes fitted with glass vials were placed over patches of scales. The boxes were cut to fit the curvature of the tree and were cemented to the bark by the use of modeling clay. No parasites were found, but this phase of the work must be further investigated before conclusions can be drawn.

W. F. Sellers, stationed at the Bureau of Entomology substation at Budapest, Hungary, has noted the occurrence of some natural enemies, mostly predacious beetles, in the forests of Germany. It is hoped that some of the more important species can be shipped to America next year for colonization.

SURVEY OF CONDITIONS IN SOUTHEASTERN MAINE.—During October 1933 a survey of conditions in southeastern Maine was made. Thirty-seven plots of 50 beeches each were laid out in that part of Maine

FIG. 12.—American beech heavily infested with the beech scale. Beverly, Mass. September 1931.

east of Augusta and extending to the Saint Croix River, which borders New Brunswick, including the two most heavily infested localities in New England. No plots were over 40 miles from the coast except in the extreme eastern portion.

The plots, averaging one-fifth of an acre, were taken at random, and it is believed that they were representative of conditions in the region covered. A description of each plot was made, the location, approximate area, slope, composition of the stand, and the number of dead beeches in the area covered by the plot being noted. All the beeches were tagged and examined, and the following information was obtained for each tree: Average diameter (breast height), condition, crown class, degree of infestation by the scale, presence of *Nectria* sp. (a fungus which apparently attacks beeches infested by the scale), other fungi attacking the tree, presence of slime flux, and natural enemies of the scale.

The beech scale was found in 24 of the 37 plots. Thirty-five dead beeches were found in the area covered by the plots. These were mostly mature and their death could not be definitely attributed to the scale or to fungous or other diseases following in its wake.

Of the 1,850 beeches examined, 45.1 per cent were infested by the scale, 3.1 per cent by *Nectria* sp., and 7.4 per cent possessed slime fluxes. The *Nectria* and slime fluxes were found, in over 90 per cent of their occurrences, on trees infested by the scale. There seems to be no doubt as to their association with the scale. Ehrlich (*3*) reports that in the Canadian Maritime Provinces 90 per cent of all beeches over 3 inches in diameter at breast height are infested by the *Nectria* and that about 50 per cent of the trees are dead in localities where the attack has been in progress for several years. If conditions in southeastern Maine are as favorable for the insect and the fungus as farther east, it would appear that the infestation of both scale and *Nectria* is comparatively new, for as yet no such condition exists as that described in the Maritime Provinces of Canada. One plot, located in Washington County, was an outstanding example in that 42 of the 50 trees were heavily infested by the scale, and yet no trace of the fungus could be found. It is also interesting to note that where the *Nectria* does occur the attack of the fungus is, in the majority of cases, light. Only 10 trees were recorded as suffering severe attack from this fungus.

The slime fluxes were, as a rule, small, averaging probably not more than one-half inch in diameter.

In analyzing the data collected in connection with this survey another fact was outstanding. The general health of trees infested by the scale was impaired to a much greater degree than that of uninfested trees. Of

the 1,850 trees in the 37 plots, 1,410 were recorded as in good condition, 287 as fair, and 153 as poor. Of the good trees, 62.8 per cent were uninfested and 37.2 per cent infested. In the case of fair and poor trees the relation was reversed. Of the trees in fair condition 68.3 per cent were infested and 31.7 per cent uninfested, and of the poor trees 78.4 per cent were infested and only 21.6 per cent uninfested.

In summing up, the survey made in southeastern Maine showed at least three significant facts:

1. The *Nectria*, although apparently definitely associated with the scale, has not as yet reached epidemic proportions.
2. Slime fluxes are distinctly more abundant on trees infested by the scale.
3. The general health of trees infested by the scale is impaired to a much greater degree than that of uninfested trees.

Further study is necessary in order to determine definitely the extent of injury to beeches caused by the scale and the part played by the fungous and other secondary diseases.

More intensive scouting of beech areas should be done in order to determine the present distribution of this insect. When this is known it would probably be advisable to attempt eradication of small isolated infestations removed some distance from generally infested areas. In generally infested areas thorough control measures are recommended in the case of ornamentals, in order to preserve the trees and to reduce the infestation to a minimum; in forest stands, however, thorough control would be extremely difficult.

One needs only to survey the situation in the Canadian Maritime Provinces to become cognizant of the potential danger that exists in connection with this minute insect which is slowly but surely invading the beech areas of New England.

Literature Cited

1. Collins, C. W. The Beech Scale (*Cryptococcus fagi* Bärenspr.), recently discovered in New England. Jour. Econ. Ent. 25 (1): 144–145. Geneva, N. Y., Feb. 1932.
2. Ehrlich, J. The Occurrence in the United States of *Cryptococcus fagi* (Baer.) Dougl., the Insect Factor in a Menacing Disease of Beech. Jour. Arnold Arboretum 13: 75–80. Lancaster, Pa., 1932.
3. Ehrlich, J. *Nectria coccinea* on Beech. Phytopathology 23 (1): 10. January 1933.
4. Hewitt, C. Gordon. Note on the Occurrence of the Felted Beech Coccus, *Cryptococcus fagi* (Baerens.) Dougl. in Nova Scotia. Canadian Entomologist 46: 15–16. 1914.

5. RHUMBLER, L. Über das Schicksal der von der Buchenrindenwollaus (*Cryptococcus fagi* Bsp.) befallenen Buchen. Zeit. Angew. Ent. 18 (3): 590–614, illus. Berlin, 1931.

SPRAY EXPERIMENTS FOR THE CONTROL OF THE EUROPEAN PINE SHOOT MOTH

By R. B. FRIEND and A. S. WEST, JR., *Connecticut Agricultural Experiment Station and Yale University School of Forestry*

It is our opinion that any spray applications made in an attempt to control the European pine shoot moth (*Rhyacionia buoliana*) should be applied to either the egg or the early larval stages. The location of the eggs on the trees and the early larval feeding habits indicate that an ovicide or a larvicide or a combination of both should be efficient. Previous laboratory experiments demonstrated the effectiveness of a two per cent summer oil in killing eggs and of lead arsenate against young larvae (Friend and West, 1933). It was also found that a mixture of 0.5 per cent nicotine sulfate and 0.5 per cent Penetrol, both by volume, was fairly effective as an ovicide. It is possible that an effective application of a stomach poison could be made in the spring when the larvae are leaving their hibernating quarters to bore into the newly developing shoots, but this possibility has not yet been investigated. Hamilton (1931), in New Jersey, considered that much of the effectiveness of a nicotine sulfate-Penetrol mixture was due to the killing of adults. Since adult emergence occurs over a six-weeks period and there is a preoviposition period of but one or two days, an attempt to kill adults alone would not seem practicable.

During the past summer field experiments were carried out in red pine stands at Middletown and at Branford, Connecticut. At Middletown a block of approximately 50 trees, averaging six feet in height, was used for each test, with adjacent trees in the same stand as controls. To one block was applied a mixture consisting of two gallons of a light summer oil[1] plus three pounds of lead arsenate in 98 gallons of water. To a second block was applied a solution containing three pounds of lead arsenate and one quart of fish oil in 100 gallons of water. At Branford the trees were 10 to 15 feet high and four or five trees were used for each test with adjacent trees again serving as controls. A mixture of nicotine

[1]In this case the oil used was Verdol, a highly refined petroleum product from which many of the constituents injurious to foliage have been removed, and containing, as marketed, 67 per cent oil and 33 per cent inert matter.

sulfate 0.5 per cent, Penetrol[2] 0.5 per cent, both by volume, and lead arsenate at the rate of three pounds to 100 gallons was used on one group of trees, while on a second block the same mixture was applied with the exception that the nicotine sulfate content was changed to 0.25 per cent.

On the basis of previous life cycle studies the sprays were timed in relation to adult emergence, oviposition and larval habits. In each test three applications were made at ten day intervals, namely: June 13, 23 and July 3, using a spray gun with 200 pounds pressure at the pump. Approximately two gallons of solution per tree per application were used at Middletown and three gallons at Branford. Less spray solution would possibly be effective, but it is essential that the insecticide run down the twigs and needles and accumulate at the needle bases. This was more easily achieved in the last application than in the first, as in the latter case the needles were more closely applied to the twigs.

Control estimates were obtained by examining all the tips on sample trees at Middletown, but only the tips of the four upper whorls and the leader at Branford. The infestation on taller trees tends to concentrate at the top. The counts were made August 28.

The results are summarized in the following table:

Insecticide	Infested tips	Uninfested tips	Control per cent
Verdol-lead arsenate	94	1,374	93
Fish oil-lead arsenate	45	1,029	95
Checks	780	96	11
Nicotine sulfate 0.5%-Penetrol-lead arsenate	10	228	94
Nicotine sulfate 0.25%-Penetrol-lead arsenate	41	259	80
Checks	177	77	30

The degree of control is calculated by subtracting the per cent infested in the treated from the per cent infested in the checks and dividing the result by the per cent infested in the checks.

From the above figures three of the insecticides appear about equally effective. However the summer oil mixture caused severe burning of the foliage, particularly the older needles, and wilting of the current twig growth. Recovery from this wilting has been gradual but is not yet complete. There has been no needle fall to date on either the new or old growth. The cost of the nicotine-Penetrol mixture is excessive, so the lead arsenate-fish oil seems most practicable, although its use on ornamental trees might be objectionable since the arsenate remains as a visible coating for a considerable time. It may be possible to omit either the second or third application without detracting from the control

[2]Penetrol is the trade name of a sulfonated oxidation product of petroleum for which is claimed an addition to the insecticidal properties of nicotine sulfate.

effected. Single applications of the lead arsenate-fish oil mixture as well as of the nicotine sulfate 0.5 per cent-Penetrol-lead arsenate spray on July 3 proved wholly ineffective. Likewise three applications of Calcium arsenate dust applied to trees 20 feet high from a truck failed to give appreciable results.

Hamilton (1931 and 1932), in New Jersey, has secured good results by spraying with a nicotine sulfate-Penetrol mixture without the addition of a stomach poison, and Glasgow (not published) in New York, secured excellent results with rotenone sprays. We have not yet given either a thorough trial, and either mixture is more expensive than the lead arsenate-fish oil spray.

References

FRIEND, R. B., and A. S. WEST, JR.: (1933) The European pine shoot moth. Yale University: School of Forestry Bull. 37.

HAMILTON, C. C.: (1931) Tests on the control of several insects attacking ornamental plants. Jour. Ec. Ent. 24: 162–169.

———— (1932) Investigations of insects injurious to ornamentals. The European pine shoot moth. Fifty-second Ann. Rep. N. J. Agri. Coll. Exp. Sta., etc., for the year ending June 30, 1931: 247–251.

THE WILLOW FLEA WEEVIL, *ORCHESTES RUFIPES* LEC., AND ITS CONTROL IN MAINE

By R. W. NASH, *Assistant Entomologist, Maine Forest Service*

The willow flea weevil, *Orchestes rufipes* Lec., was first called to the attention of the Maine Forest Service in 1926. At this time it was causing slight damage to the laurel-leaf willow, *Salix pentandra* Linn. in the vicinity of Kennebunk Beach. In mid-August, 1931, it was again called to our attention. Property owners were greatly alarmed and appealed for help in controlling it. Local arborists and gardeners had been unable to find any control for the insect although they had tried all the insecticides of which they knew. The injury at this time was so severe that the foliage was either entirely browned or badly spotted by the mines of the grubs.

The laurel-leaf willow, a native of Europe and Asia, is very attractive with its shiny dark-green foliage. It is principally used as an ornamental hedge and as such is cut back severely every year. A few mines to a leaf are enough to cause anxiety to the owners to say nothing of their anguish where whole trees are browned.

The distribution of the willow flea weevil is widespread. It is found in

eastern Canada, northeastern United States south to New Jersey, in scattering north central states, northwestern United States south to New Mexico and north to Alaska. In view of this, however, only three records have been found which speak of any abundance of this insect in the past. These are from Ontario (1), New Jersey (2), and Utah (3).

The adult weevil is somewhat of a general feeder as found in Maine although the principal host is willow. Adults feed abundantly on the introduced species of willow, *Salix pentandra* and *S. babylonica*, and on the native *S. discolor*, *S. lucida* and *S. nigra*. In the vicinity of infested willows they have been found feeding and abundantly on amelanchier, apple, cherry, craetaegus, gray birch, pear, poplar, red oak, white birch, lilac, syringa, golden rod, hard hack and lightly on grasses, elm and red maple. In Maine the grubs have been found to confine their attack almost entirely to willow, but are found occasionally in poplar. It is interesting to note that *Salix pentandra* is by far most seriously mined even when our native willows are in the immediate vicinity. Another introduced species, *Salix babylonica*, is also attacked by the grubs.

The damage done by the willow flea weevil consists in the feeding punctures of the weevils and the mines of the grubs. Early in the season the adults feed to quite an extent on the tips of sprout growth, oftentimes killing them. Here they feed by eating out a circular to oval hole in the young growth. The great majority of adult feeding is done on the underside of the leaves. Inserting the beak they eat out the soft leaf tissue leaving the epidermis of the opposite side. These shallow pits are circular and about .8 mm. in diameter. The completed pit shows the beak to have been inserted on one side of the hole. The actual puncture takes out from ⅓ to ½ of the lower epidermis of the hole. Feeding punctures similar to those on new growth shoots are often made on the under mid-rib.

The mining of the leaves by the larvae causes by far the most severe injury as evidenced by the fact that estate owners neither seem to notice the injury nor complain about it until the mines get well developed. Trees heavily infested by grubs appear as if scorched by fire, and the last of August lose from a few to all of their leaves. Even in less severe cases such trees are spoiled as ornamentals for the mines contrast plainly with the normal shiny green of the foliage. The grubs mine in the upper surface of the leaf and make a blotch mine. The upper surface of the mine is slightly blistered.

On such willows as are cut back severely each year the damage to a tree is practically all from an ornamental viewpoint. On trees not so cut back there is, from repeated injury, a killing back of the tip growth and

also a generally weakened appearance and sparseness of foliage. This is due to the number and large size of leaves put out on the sprout growth of pruned trees.

There is but one generation of the insect per year. The adults hibernate in soil beneath the trees, in sod, rubbish, beneath stone walls, and beneath loose bark or cavities. They start emerging the middle of May at which time the willow buds are opening. Many of them in leaving their winter quarters crawl up the trunk of the tree but the majority of them crawl up on grass blades or similar things and either spring to low hanging twigs or fly to branches above. They feed during May, all of June and far into July. Mating begins the first week in June and egg laying starts about the middle of June. In 1933 eggs were found to be abundant on June 19, and by the first part of July the majority of the eggs are laid. Eggs are laid anywhere in the leaf tissue and are inserted in cavities similar to feeding punctures. Oviposition occurs over a period of usually about a month as found from caged specimens. The egg does not occupy the entire egg cavity but lies in the further part and between the upper epidermis and that part of the lower epidermis which remains when the cavity is made by the adult. The length of the egg stage averages about ten days. The grubs start feeding as soon as they hatch. Pupation occurs in the center of the mine, about fifty days elapse from the laying of the egg to the appearance of the adult. The adults are very abundant again the last of August at which time they feed. They start going into hibernation with the advent of the first frosts.

The egg is white, oval to circular in shape, about .4 mm. long and .3 mm. wide. The full grown larva is about 3 mm. long, dirty flesh color with a dark brown prothoracic shield divided along the center line. Dark transverse spots are along mid dorsal area from the first abdominal segment back and mid ventral area from 2nd abdominal segment back. The head is dark brown and about .41 mm. wide. The pupa is at first white, later becoming almost black. The adult is an elliptic black weevil about 2.3 mm. long and with thin grayish pubescence. The legs and antennae are reddish yellow and scutellum is white.

CONTROL.—With such a long adult feeding period it was thought that these beetles could be controlled by applying a stomach poison as soon as the leaves became grown. However, tests with lead arsenate sprays and dusts of sodium fluosilicate and hydrated lime gave so little kill of the adults that these insecticides were not considered of value to use.

Bordeaux mixture was tried as a repellant. Caged specimens which were allowed a choice of feeding on sprayed or unsprayed foliage preferred the latter. The sprayed leaves had 87% less feeding punctures.

In the field however, such a degree of control was far from being reached. The population here on sprayed trees was cut down but 33%. Bordeaux mixture therefore is not practical.

A contact spray of nicotine sulphate 1–600 plus liquid potash soap 1–500 proved to be the most effective. Results have shown that for absolute control it is necessary to spray with this twice. The first time the spray is used to kill adults and eggs and at a time when eggs are first being laid in numbers. This is about June 19 in Maine. The second application should be about three weeks later and is to kill grubs and eggs. These two applications give 99% control. Soon after the grubs change to the second stage the percentage of kill drops.

By spraying once the best percentage of control obtained was a 93% reduction in mines. This percentage of reduction improves the appearance of the foliage to a great degree over that of unsprayed trees and would be passable yet the leaves still appear quite spotted from the mines and are still poor from an ornamental viewpoint which is paramount in this case. If a single application be used it should be applied on either one of the above dates. Nicotine sulphate should be used as above.

Spraying causes the adults to drop to the ground. For this reason during spraying experiments sheets were spread beneath the trees to catch the beetles in order to get spray counts. It is also for this reason that the ground beneath trees should be sprayed to be sure to wet all weevils.

References

1. Gibson, Arthur. [Notes on *Orchestes rufipes* Lec.] Ontario Ent. Soc. Rpt. **41**: 15, 1911.

2. Weiss, H. B., and Lott, R. B. Notes on *Orchestes rufipes* Lec. in New Jersey. Psyche *28:* 152–155, 1921.

3. Jones, W. W. Notes on *Orchestes rufipes*. Journ. Ec. Ent. *15:* 179, 1922.

SOME OBSERVATIONS ON THE BALSAM WOOLLY APHID IN MAINE

By H. B. Peirson and A. M. Gillespie, *Maine Forest Service, Augusta, Maine*

The balsam woolly aphid (*Adelges piceae*) has become very destructive to balsam fir (*Abies balsamea*) in Maine. It no doubt has been present for some time and has been gradually increasing in abundance. As long ago as 1916 Kotinsky (1) reported this insect as killing fir in New Hampshire. During the past three years it has been found in thirty-four townships scattered over the southern half of Maine. In some places infestations found have been limited to a few trees while in other areas sizable stands of fir have been killed.

The insect appears as white flocculent masses on the bark and buds. Trunks of trees often appear whitish due to the presence of the insect. There are two distinct types of injury. In one case attack is concentrated on the branches, twigs and buds bringing about a "gouty" appearance in which twigs become swollen and distorted. The buds become enclosed in the swollen tissue causing them to die and often resulting in a complete cessation of foliage growth. A swollen condition at the nodes is quite common. The crowns become thin, stunted, and taper off rapidly. In the other case attack is confined largely to the trunk, often to such a degree that trees are killed rapidly. Such trees at a distance appear as if scorched by fire. The "gouty" condition may or may not be present in the latter type. In general, the swollen twig condition is more prevalent along the coast.

Balch (2) has made a detailed study of this insect and its injury in Nova Scotia and the southern part of New Brunswick. Trees killed and infested by the balsam woolly aphid were found this past summer in New Hampshire and Vermont. It is thoroughly established in Maine and the damage by it is on the increase. Since fir is a very valuable tree in Maine the situation needs thorough investigation. Balsam fir not only ranks second for pulp in the state but also is cut to a large extent for Christmas trees.

There are at least two generations of the balsam woolly aphid at Bar Harbor. It overwinters as immature nymphs beneath the bark scales, in bark crevices, and at the base of the buds, reaching maturity the middle of June. Eggs are then laid around and beneath the bark scales or on the smooth surface of the bark, at times almost completely surrounding the female. Crawlers are abundant for the first three weeks of July, maturing the last of August. Eggs are again laid at this time and

during early September after which they hatch, overwintering as immature larvae.

The egg is oval, approximately 0.35 mm. in length and 0.19 mm. in width. It is yellow in color when first laid, becoming light brown as the embryo develops.

The newly-hatched nymph or "crawler" is yellow and about 0.44 mm. in length. The body is flattened and oblong with well developed legs. The white waxy fringes are not apparent in this stage but appear rather conspicuously a short time after the larva commences to feed. Many of the larvae migrate to the tips of the new growth where they congregate at the base of the needles and buds. Some of them settle on the new succulent needles and derive their food from them. As they reach the adult stage they become covered with white waxy threads.

The ovipositing females are reddish brown to black in color. They are approximately 0.65 mm. long, 0.44 mm. wide, wingless and with well developed legs.

Spraying experiments in 1932 and 1933 have shown that this insect may be satisfactorily controlled on valuable or ornamental trees by spraying with nicotine sulphate, one part to 600 parts of water plus either one-half per cent Penetrol or one per cent Verdol, during the middle of June or the middle of August. High pressure is desirable. The entire tree should be thoroughly drenched in order to kill the eggs and ovipositing females, which are well protected by a white waxy covering secreted by the female, and to kill the immature forms of which many are beneath the bark scales. Tips of new growth should also be drenched so as to kill the "crawlers" which tend to congregate there.

A control for this insect in the forest has not as yet been found. Timberland owners are being advised to cut infested trees and either salvage or burn them whenever feasible. This will help to prevent the spread of the insect through the rest of the stand. No natural control for this pest has been noted in Maine.

Literature

1. Kotinsky, J. The European Fir Trunk Bark Louse (*Chermes* (*Dreyfusia*) *piceae* Ratz.) Apparently Long Established in the United States. Proc. Entom. Soc. Wash. 18: 14–16, 1916.
2. Balch, R. E. The "Gout" Disease of Balsam Fir. The Forestry Chronicle, Feb. 1932.

PREDATORY CHECKS, ESPECIALLY BIRDS, ON THE BIRCH LEAF-MINING SAWFLY, *Phyllotoma nemorata* FALLEN[1]

By A. E. BROWER, *Field Entomologist, Maine Forest Service*

This recently introduced sawfly became epidemic in Maine in 1927. Regarded as rare thruout most of its wide European range, it swept like a blight over the birch forests of northern New England. Larvae are found in the leaves from July to late October. During September and October they transform to prepupae in a lens-shaped hibernaculum within the mine from which the adult emerges the next June and July. Preliminary studies which were started in 1928 did not not show any important biological check upon this sawfly.

During the fall of 1928 in two localities in southern Maine numbers of hibernacula were found destroyed, apparently by birds. In the fall of 1929 the Maine Forest Service started annual counts, hereafter termed "the survey", to determine the status of the sawfly. Counts made on twenty representative plots distributed thruout the white birch belt of Maine comprise a "survey". "The survey" in 1929 showed the destruction of about 10% of the larvae and prepupae by birds, probably 6–7% being prepupae after the hibernacula were formed. The 1930 "survey" was on a slightly different basis but indicated some increase in the percentage destroyed. Birds were observed feeding on the larvae in the leaves on the trees in both 1929 and 1930. During the last three years counts have been made for the percentage of empty hibernacula. In 1931 "the survey" showed the destruction of 18.24% of the hibernacula in the thirty day period following their formation. By 1932 this destruction had mounted to 53.43% and in 1933 was 47.96%. This all took place in a period averaging about fifteen days before and fifteen days after the infested leaves fell. All evidence leads the author to believe that birds are responsible for practically all of this destruction. To these figures must be added the destruction of 20% or more of the larvae by tree-feeding birds removing them from their mines in the leaves.

Birds have been observed feeding on larvae in the leaves from early August on. Chickadees seem to be the most persistent feeders; individuals have been watched flying from one white birch to another and feeding largely on this insect. Some individuals and bands appear to feed more extensively on the sawfly than others. The redstart, Maryland yellowthroat, myrtle, magnolia, parula, and black-throated green

[1]Journal paper of Maine Forest Service, published with the approval of H. B. Peirson.

warblers have all been observed feeding on the sawfly larvae, and other warblers doubtless have similar habits. Red-eyed vireos have been seen many times ripping open the mines, and blue-headed vireos were fairly positively seen in the act of opening mines. Goldfinches destroy large numbers on some seed-bearing birches, apparently attracted to the trees by the seeds. On one large heavily infested tree most of the larvae and prepupae were destroyed one year; feeding has been observed by several different workers during three seasons. Juncos rip open the mined leaves on the trees to some extent. They feed on the prepupae in the fallen leaves much more extensively. Juncos are the only species positively seen feeding both in the trees and on the ground.

The mined leaves tend to be the first to fall from the trees and ground feeding birds destroy large numbers of prepupae, especially while the leaves are falling. White-throated, song, fox, and white-crowned sparrows are the most important. Leaves overturned by fox sparrows have been examined several times and nearly every hibernaculum found shattered by their heavy bills. Two caged song sparrows ate sixty-two prepupae in three hours. This fall leaves scratched over by a flock of robins were examined and many freshly opened hibernacula found. Thrushes are believed to feed on the prepupae in fallen leaves. A hermit thrush which was being watched appeared to remove a prepupa from its hibernaculum, found to be freshly opened on examination.

The foregoing figures upon the percentage of larvae and prepupae destroyed by birds, amounting to 20% or more of the larvae and about 50% of the prepupae during the last two years, do not include the destruction by birds from the time of "the survey" to the emergence of the adults the following June and July. The amount of definite data on this point is small but the figure is believed to amount to several per cent. The statement can also be made that a higher percentage is destroyed in the southern part of Maine below the white birch belt. The data secured strongly indicate that birds have been the most important predatory check upon the birch leaf-mining sawfly during the last three seasons and probably have been as important as all other predators combined.

Other predatory enemies appear to be much less important than birds. On the trees larvae and prepupae are attacked by chrysopid larvae, ants, wasps, and other Hymenoptera. Ants and chrysopid larvae are important on small groups of young birch, but ants are certainly of minor importance under forest conditions. After the leaves fall, shrews, mice, carabid beetles, wireworms, and ants attack the prepupae. A captive shrew destroyed 131 prepupae in about 12 hours. Captive

carabid beetles readily fed on the prepupae. The percentage destroyed by predators other than birds appears to be low under forest conditions.

This great destruction of an introduced insect is the more remarkable because birds have not been observed feeding on the native leaf miners in Maine. Species of Lithocolletis, Cameraria, and Brachys are found in considerable numbers about the laboratory at Bar Harbor where the heaviest feeding by tree-frequenting birds was observed. No sign of bird feeding on the native miners was found upon examining heavily infested trees nor was any noted in the fallen leaves. Both the lack of feeding on native species and the remarkable increase in the precentage of birch leaf-mining sawfly larvae and prepupae destroyed indicate that the birds have acquired a new food habit. The full depth mine and rather large size of the introduced species may account for this.

INSECT CONTROL WORK BY THE CIVILIAN CONSERVATION CORPS IN CONNECTICUT

By GEORGE H. PLUMB and HENRY W. HICOCK

The insect pest program in the Civilian Conservation Corps Camps in Connecticut has been separated into two projects, namely: the work done on trees affected by white pine weevil, *Pissodes strobi* Peck, and that done to eliminate as much as possible of the European pine shoot moth, *Rhyacionia buoliana* Schiff. The first has been confined chiefly to state-owned lands, while the second is more general in its scope. The supervision of this work is under the direction of the Connecticut Agricultural Experiment Station.

The weevil control work was carried on between June 25 and August 15 from seven camps. In view of the flight habits of the insect it was deemed advisable to treat all the pine stands over relatively large areas rather than confine the work to those most seriously affected. The size of these areas varied from 100 to 4,000 acres and the infestation therein varied from zero to 50 per cent. It so happened that this was an especially good season to do such work, since observations of Dr. H. J. MacAloney of the Bureau of Entomology indicated that this year's weevil brood in northeastern United States is much smaller than usual.

During the working period some 50 men from the Civilian Conservation Corps Camps were employed in removing weeviled tops with pruning shears and in some instances pole cutters. The foremen used in this work had all had previous training or experience in forestry or entomology. Due to inexperience the efficiency of the crews, from a time standpoint, was about 60 per cent. The results obtained show that

1,500,000 trees located on 10,000 acres were examined, and 35,000 infested tops removed. The cost of this work ranged from a minimum of .5 to a maximum of 7.5 man hours per acre. In the latter instance the trees varied from 3 to over 25 feet in height, averaging about 7 feet, and 183 tips per acre were removed. The infestation averaged about 30 per cent. If the men are available it is planned to repeat the work in the summer of 1934 on the same areas.

The European pine shoot moth project is more ambitious in its aims. In Connecticut the infestation is generally heavy throughout the southwestern portion of the state, and medium to light elsewhere. By starting at the northern and eastern boundaries and working southwest, inspecting every red and Scotch pine plantation in the intervening area, an effort is being made to confine the heavy infestation within its present limits in Fairfield County. Later this area will be treated also and the infested trees removed to reduce the general infestation. In the case of this insect, red pine appears to be its most seriously affected host in Connecticut, although many other species are injured by its attacks. However, Scotch pine is the only other common forest tree that is severely injured in this state, so control measures are being confined to these two species.

The control measures consist of removing and burning all infested tips except where the trees are very heavily infested and injured beyond hope of recovery. In the latter case the trees are cut down and burned. All areas will be treated again in May before the adult moths emerge.

As a supplementary aid to the above outlined shoot moth program, on the 4th of December, 171 men from the Civil Works Administration project were assigned to the work for a period of 10 weeks. Of these men, one is general superintendent and 10 are foremen, each of the latter having charge of a crew of 16 men.

The control measures undertaken on this project will be chiefly on the larger municipal and privately owned watersheds, as well as any plantations omitted in the preceding work. In addition to merely clipping the infested trees, these men will be used in cutting down and burning plantations which are 100 per cent infested, and for which there is no hope of ultimate recovery.

It is hoped that eventually all the pine areas in the state will have been inspected, and the infested trees either clipped or destroyed. Our observations to date on the habits of this insect and its relation to red pine indicate that the normal spread is slow and that if the trees are not infested before the stand closes the injury will not be serious. This forms the basis for the general control program.

A SECOND REPORT ON CODLING MOTH[1] BANDS IN PENNSYLVANIA[2]

By H. N. WORTHLEY, *Pennsylvania Agricultural Experiment Station*

TOXICITY AND ATTRACTIVENESS OF BANDS.—In 1932 and 1933 bands of corrugated strawboard treated with a hot mixture of 1 pound beta-naphthol in 1.5 pints of lubricating oil exhibited the high degree of killing power against trapped codling moth larvae reported for previous tests (1)[3]. Less than 1% summer moth emergence occurred in 1932, with 6.2 inches of rainfall during July and August. In 1933, when rainfall for these two months totaled 16.0 inches, moth emergence ranged from less than 1% to 2%. In 1932 a cold dipped band with oil of 102 viscosity allowed 2.9% emergence, but in 1933 the best band tested was cold dipped, using 300 viscosity oil.

Variations in toxicity of bands, as noted by Farrar and Flint (2), seemed to be caused more by differences in the uniformity and persistence of the chemical coating than to the weight of chemicals deposited in the bands. As might be expected, the kill was higher within the tunnels of the band than between the band and the bark of the tree. Treatments of sufficient uniformity and persistence to kill a high percentage of larvae in the latter situation were the most effective. (Table 1).

TABLE 1. TOXICITY OF CODLING MOTH BANDS, FLORA DALE, 1932. 2-INCH BANDS. EXAMINED IN SPRING, 1933

Band No.	Treatment Oil vis.	No. dips	Method	Chem. per ft. gms.	Total larvae trapped	Bet. band and tree Trapped %	Bet. band and tree Dead %	Within tunnels Trapped %	Within tunnels Dead %	Ave. %
1	280	2	Hot	12.0	942	60.8	91.2	39.2	99.1	94.4
2	100	2	Hot	29.8	959	48.9	87.2	51.1	99.1	93.3
3	280	2	Hot	17.2	589	48.0	86.5	52.0	96.4	91.7
4	100	1	Hot	16.6	797	35.8	56.6	64.2	92.7	79.8
5	102	2	Cold	7.1	620	41.6	43.0	58.4	77.2	62.7
6	Treated crepe paper				467	98.2	42.9	1.8	62.5	43.3

Many Pennsylvania growers band with strips of untreated burlap wrapped once or twice about the trunks, and inspect the bands periodically during the summer. The reasons advanced for this practise include the cheapness of burlap, availability of labor for inspection, fear of injury to trees from treated bands, and the idea that burlap would make a better trap. The trapping effectiveness of various types of

[1] *Carpocapsa pomonella* Linn.

[2] Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station, Dec. 18, 1933, as Technical Paper No. 624.

[3] Numbers in parenthesis refer to "Literature Cited."

banding material was tested by the method suggested by Cutright and Houser (3). Bands to be compared were arranged on paired posts in the following manner:

	Post No. 1	Post No. 2
Upper— 12 in. from top of post	Band No. 1	Band No. 2
Lower— 18 in. from top of post	Band No. 2	Band No. 1

Three pairs of posts were used, and for each test 50 freshly cocooned larvae from banded trees were placed singly at intervals of time on top of each post. At the end of 24 to 30 hours the bands were torn apart, and the catch in each type recorded. The tests of greatest interest are recorded. Table 2.

TABLE 2. COMPARATIVE CATCH OF CODLING MOTH LARVAE IN PAIRED BANDS ON POSTS. STATE COLLEGE, PA., 1932

Types of band compared		Larvae trapped	
Band No. 1	Band No. 2	Band No. 1 Per cent	Band No. 2 Per cent
Untreated bands			
4-in. 1-ply burlap	4-in. 3-ply burlap	22.1	77.9
4-in. 2-ply burlap	4-in. 3-ply burlap	36.7	63.3
2-in. strawboard	4-in. 3-ply burlap	55.6	44.4
2-in. strawboard	4-in. strawboard	41.3	58.7
Treated vs. untreated			
4-in. Band No. 1*	4-in. 3-ply burlap	75.1	24.9
2-in. Band No. 5*	4-in. 3-ply burlap	75.0	25.0
2-in. Band No. 1*	2-in. strawboard	50.0	50.0
2-in. Band No. 5*	2-in. strawboard	55.0	45.0
Treated vs. treated			
2-in. Band No. 1*	2-in. Band No. 3*	53.2	46.8
4-in. 300 vis.	2-in. 300 vis.	50.3	49.7

*See Table No. 1 for treatments.

In these tests, where a choice was offered to cocooning larvae, three thicknesses of burlap made a better trap than one or two thicknesses. Corrugated strawboard was superior to 3-ply burlap. Treated strawboard bands trapped many more larvae than untreated burlap, but few more than untreated strawboard. No marked differences in the trapping ability of fresh treated bands appeared, even in comparisons of 4-inch with 2-inch width. Crowding of larvae was not a factor in these tests, for an even distribution of the numbers involved gave 1.4 larvae per inch of band.

It was observed that larvae sometimes made several selections of cocooning places before finally settling down to spin a cocoon. This tendency to wander was less marked in the strawboard than in the burlap. In the fresh treated bands the larvae became paralysed very quickly, and wandering was reduced to a minimum. This appeared to

account in large measure for the high percentage located in treated bands. The wandering was chiefly a one way trip. In many of the treated bands over 95% of the larvae died during the period of the test. When air temperatures rose above 90°F the kill was usually complete.

BAND CATCH VERSUS TOTAL POPULATION.—Discussion following the report of Farrar and Flint (2) produced estimates of band catch varying from 8%, where exit holes in fruits were compared with larvae in bands, to 83% where hibernating larvae on the trees were compared with those in the bands. From his own experience and the reports of other workers, the writer believes that the vast majority of codling moth larvae cocoon upon the trees, even in sod orchards, and that the fairest estimate of band catch can be made by the thorough examination of all possible cocooning places on banded trees. Estimates of percentage of total population caught in bands appearing in this paper have been made in this way. Figures indicating a catch of 96.8% of the total population have already been reported (1). Three more trees in this block were examined in the spring of 1933, and the figures indicated that 96.2% of the larvae reached the bands. This block of old trees had been thoroughly scraped and pruned for several years. Records obtained in commercial orchards are presented in Tables 3 to 5.

TABLE 3. LOCATION OF CODLING MOTH LARVAE ON TREES, 1932–33

Location of larvae	Mature York—McKnightstown Before scraping Spring, 1932 15 trees		Mature York—McKnightstown Scraped, 1932 Spring, 1933 2 trees		Mature Grimes—Biglerville Not scraped, 1932 Spring, 1933 4 trees		Mature Grimes—Biglerville Scraped, 1932 Spring, 1933 1 tree	
	No.	%	No.	%	No.	%	No.	%
Trunk.....	435	36.0	0	0.0	53	28.7	0	0.0
Crotches...	140	3.4	1	0.4	8	4.3	1	1.9
Heavy branches	479	39.6	1	0.4	0	0.0	0	0.0
Light branches	254	21.0	16	7.4	124	67.0	8	15.1
Total on trees..	1208	100.0	18	8.2	185	100.0	9	17.0
In bands...			197	91.8			44	83.0

On the scraped trees at McKnightstown (Table 3) over 90% of the larvae reached the bands. The distribution of the remaining larvae on these trees, when compared with the situation before scraping, showed that individuals cocooning among the upper branches were least disturbed by the treatment. The same thing occurred at Biglerville, but here the bands trapped only 83%. Nearly all the rest were in cicada scars, split branches, and rotting pruning stubs, which were plentiful in the upper parts of the trees. On the unscraped trees 67% of the larvae were in such places.

In 1933 trees bearing treated bands were examined superficially at intervals during the summer, and in the fall three of them were gone over very thoroughly. The distribution of dead and living individuals, and of pupal skins, was recorded. Table 4.

TABLE 4. LOCATION OF CODLING MOTH ON TREES, 1933, ARENDTSVILLE, MAIDEN BLUSH, 3 TREES

Location	Dead		Living		Emerged		Total	
	No.	%	No.	%	No.	%	No.	%
Trunk.....	4		6		1		11	0.9
Crotches...	10		12		14		36	2.9
Heavy branches	18		20		26		64	5.2
Light branches	30		42		50		122	9.8
Total on trees..	62	26.2	80	34.3	91	39.1	233	18.8
Bands—treated..	900	89.9	94	9.4	7	0.7	1001	81.2
All locations	962	77.9	174	14.1	98	8.0	1234	100.0

At Arendtsville (Table 4), the bands trapped 81.2% of the larvae, and about half the rest were located among the smaller branches. Of greater importance was the fact that whereas only 0.7% of the larvae in the bands produced moths, emergence from larvae on the trees totaled 39.1%. Thus of the total worm population, 8.0% produced moths, rather than a fraction of 1%, as indicated by the band record alone.

In the Grimes block at Biglerville a similar study was made. Here the worms were removed from untreated burlap bands twice weekly, and reared in cages. Table 5.

TABLE 5. LOCATION OF CODLING MOTH ON TREES, 1933, BIGLERVILLE—GRIMES

Location	Scraped and banded, 3 trees				Not scraped and banded, 3 trees			
	Pupa skins		Total		Pupa skins		Total	
	No.	%	No.	%	No.	%	No.	%
Trunk.....	3		14	3.1	58		358	59.4
Crotches...	3		5	1.1	12		31	5.1
Heavy branches	11		27	6.1	24		96	15.9
Light branches	25		85	19.0	17		117	19.6
Total on trees..	42	32.0	131	29.3	111	18.4	602	100.0
Bands—untreated..	52	16.4	316	70.7				
All locations	94	21.0	447	100.0	111	18.4	602	100.0

At Biglerville (Table 5) the bands used trapped 70.7% of the larvae. About two-thirds of the rest were among the upper branches, and the remainder mostly in cankers on the large limbs and trunk. On the unscraped trees large patches of loose, cankered wood on two of the trunks sheltered over half the larvae found.

On the unscraped trees 18.4% of the larvae produced moths. On the scraped trees 32.0% of the larvae outside the bands produced moths, and 16.4% of the larvae reared from the bands, an average of 21.0% for these trees. The undoubted loss of pupal skins from the surface of the trees may account for the lower figure for the unscraped trees. In spite of this loss, the records still show that many more larvae pupated on the trees than in the bands. In addition, on the banded trees at both Biglerville and Arendtsville, well over half the pupal skins were found among the upper branches. A smaller proportion of the pupating larvae than of the hibernating larvae reached the bands. Two possible reasons for this condition suggest themselves. Pupating larvae, cocooning for a short time only, may be satisfied with some convenient spot near the apple just abandoned, and thus fail to reach the larger limbs and trunk. Also, doubtless more early than late worms leave the apples before they drop.

The records quoted have serious implications regarding the real effectiveness of scraping and banding. Heretofore the percentage of larvae in the bands, and the percentage moth emergence from them in comparison with emergence from untreated bands, has been the standard for judgment. Figured on this basis the treated bands at Arendtsville gave 78% control of summer moth emergence, thus: they trapped 81% of the population, of which 0.7%, or 0.57% of the total, emerged. Of the 19% not trapped, 16.4%, or 3.1% of the total, emerged. Thus of all larvae produced in this orchard, 3.67% emerged, and the formula is $\frac{16.4 - 3.67}{16.4} \times 100 = 78\%$ control. But examination of the trees indicated an emergence of 21% on untreated trees, and 8% on scraped and banded trees, and the formula should be $\frac{21 - 8}{21} \times 100 = 61\%$ control. The high percentage of pupation among larvae remaining outside the bands makes thorough scraping and pruning of paramount importance. If an orchard is so well prepared that 90% of the larvae are trapped; if treated bands hold moth emergence to 1%; and if seasonal conditions and spray treatment combined hold moth emergence outside the bands to 21%, application of the formula given above indicates 85% control of summer moth emergence.

Cost of Scraping and Banding.—Many growers have hesitated to band their orchards, fearing that costs might be out of proportion to the benefits derived. Others have scraped with more or less thoroughness, and banded with old burlap sacks and furniture wrappings, hoping

that the cheapness of the material would offset the cost of the necessary inspections of untreated bands. Some figures have been gathered from growers who have kept partial records of these operations. Table 6.

TABLE 6. GROWERS' FIGURES ON COST OF SCRAPING AND BANDING

	Orchard No. 1	Orchard No. 2	Orchard No. 3
Number of trees	2425	8000	2000
Age—years	11–31	15–30	30
Man hours—scraping	790	1500	——
Man hours—banding	100		——
Cost at $.175 per hour	$155.75	$262.50	——
Number of inspections	10	——	——
Man hours—inspection	800	——	——
Cost	$140.00	——	——
Average width—burlap bands	3 in.	12 in.	12 in.
Total length—feet	5160	24000	6000
Cost of banding material	——	$45.00	——

In Orchard No. 1 the scraping was found to be insufficient, and is being done again. In Orchard No. 2 only the trunks and crotches were scraped. In Orchard No. 3 scraping was piece work at $.07 per tree, or $140.00, a figure close to that in Orchard No. 1. Experience indicates that in the average mature orchard at least one-half hour per tree should be employed in scraping and pruning to remove cocooning places. With this change, but using the figures in Table 6 on cost of bands and of inspection, a comparison has been made of 12-inch burlap (folded to 3 thicknesses) inspected 10 times, with 2-inch treated strawboard bands at $.015 per foot. Table 7.

TABLE 7. APPROXIMATE COST OF BANDING OPERATION FOR 100 AVERAGE MATURE TREES

	Burlap bands 10 inspections		Strawboard bands treated	
	Man hours	Cost	Man hours	Cost
Scraping	50	$8.75	50	$8.75
Banding	4	.70	4	.70
Inspections	34	5.95	—	——
Bands	300 sq. ft.	.56	300 ft.	4.50
Total	88	$15.96	54	$13.95

A total cost of $.14 per tree to avoid 85% of the normal attack of second brood worms and to reduce the winter carry-over of larvae 90% should not seem exhorbitant to any fruit grower who is facing the problem of codling moth control.

The cost of treated bands does not equal the cost of adequate inspection of untreated burlap bands, and more than 1% may be expected to escape the inspections. In addition, time spent inspecting bands could be better employed in thinning to break clusters and to remove wormy

fruit from the orchard. All factors considered, treated bands appear preferable to untreated bands.

LITERATURE CITED

1. WORTHLEY, H. N. Chemically treated codling moth bands in Pennsylvania. Jour. Ec. Ent., Vol. 25, No. 6, pp. 1133–43. Dec. 1932.
2. FARRAR, M. D., and W. P. FLINT. Chemically treated bands. Jour. Ec. Ent., Vol. 26, No. 2, pp. 364–73. April, 1933.
3. CUTRIGHT, C. R., and J. S. HOUSER. A laboratory method for determining the attractiveness of bands to codling moth larvae. Jour. Ec. Ent., Vol. 22, No. 1, pp. 62–64. Feb. 1929.

SOME OBSERVATIONS ON LONG DISTANCE DISPERSAL OF APPLE MAGGOT FLIES[1]

By A. I. BOURNE, W. H. THIES and F. R. SHAW, *Massachusetts Agricultural Experiment Station, Amherst, Mass.*

In the course of our studies on the apple maggot (*Rhagoletis pomonella* Walsh) and its control in commercial orchards in Massachusetts, the importance of environmental conditions surrounding commercial blocks became quickly and unmistakably apparent. In many cases this was discovered to be the chief limiting factor determining successful control of the insect or complete failure to do so, and caused especial emphasis to be laid upon the recommendation to spray thoroughly all trees in, adjoining or within 200 yards of the commercial orchards. The work of Messrs. Phipps and Dirks in Maine, on the recovery of marked specimens of apple maggot flies, has supported and verified these recommendations, particularly as to the range of dispersal. However, numerous instances of local outbreaks and of heavy infestation of apple maggot, which were difficult to explain on the basis of environmental conditions within distances hitherto considered significant (200 to 250 yards), have been noted. The problem was a baffling one unless accounted for on the basis of possible greater range in fly dispersal than previously noted. In this regard Phipps and Dirks expressed the belief that apple maggot flies might, if necessary, travel greater distances than have been recorded, particularly under favorable weather conditions. The observations reported herewith resulted from an attempt to gather data on this point and to determine, if possible, the limits of dispersal.

The location chosen for the point of release was well adapted for this

[1]Contribution No. 181 from the Massachusetts Agricultural Experiment Station.

purpose, situated at the margin of the chief onion and tobacco growing area of the Connecticut River Valley, a region of intense cultivation, broad open fields, relatively few natural barriers and (of prime importance) comparatively few fruit trees. All such trees could be readily

FIG. 13.—Looking in northeasterly direction from point of release, showing long distance of dispersal of flies. Nearest apple tree is over 500 yards from this point.

located and it was possible to release flies at almost any desired distance from apple trees.

The only apple trees within a distance of more than half a mile from the point where the flies were liberated were in a block of young Wealthy trees, not yet in bearing, at a distance of about 450 yards; a mature Wolfe River tree, well loaded with fruit, at a distance of 568 yards northeast of the liberation point; and beyond this, in the same direction at a distance of 600 to 700 yards, a small orchard of different fruits, chiefly apples. These latter were Wealthy and Duchess, both varieties susceptible to apple maggot and all the trees had a fair set of fruit. The single tree of Wolfe River received one spray all season, (none for apple maggot) and the young Wealthy and Duchess block had been completely ignored by the owner for several years and the fruit was badly infested by practically every disease and insect pest common to this region.

Phipps and Dirks have reported that natural barriers (buildings,

hedges, woodland, etc.) exert a considerable check on dispersal and that flies might travel as much as 50 yards further over open ground than when such barriers intervened. In the area included in our observations the only significant obstructions to flight were in a northeasterly direction from the point of liberation. These comprised a row of maples 60 to 70 feet high, running east and west, interplanted with young spruces and larches averaging 15 feet in height forming a continuous barrier, at 50–100 yds. distance; and a group of tobacco barns, sheds and a dwelling house with accompanying ornamental shrubbery, at a distance of more than 580 yards from the liberation point.

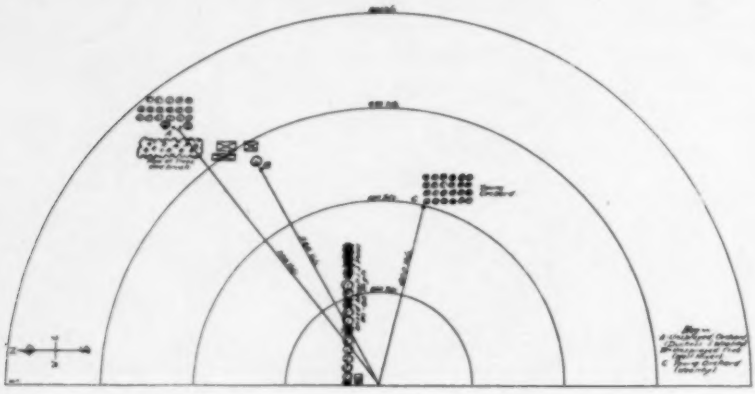


FIG. 14.—Diagram of area included in the observations, showing distance from point of release to apple trees and the double barrier between points of release and of recovery.

Approximately 1,000 specimens of marked flies furnished by Professor Dirks of the Maine Experiment Station were liberated on July 21 in a small apple tree transplanted for that purpose in a section of the State Forest Nursery. At the time of liberation weather conditions were favorable for the activity of the insects. Between July 21 and August 12 daily observations were made of the apple trees in the blocks above mentioned, and apple maggot flies collected. Collections were made each day at approximately the same time to insure uniform conditions. The weather during this period was generally favorable for the activity of the flies, with the exception of four days which were overcast with occasional rain, and several days of high wind which interfered. During this period the prevailing winds were west or southwest.

A total of 143 flies were collected during this period. In addition to these, numerous flies were observed but proved too elusive to catch.

In the first few days following liberation of the flies, marked specimens were collected in the immediate vicinity of the point of release. These were found on ornamental shrubs at a distance of approximately 60 yards. It was anticipated that the apple trees (at least those in bearing) were situated at such a distance that no recoveries of marked flies would be possible. A marked fly was collected August 5 on a young Wealthy tree 728 yards from the point of release, and later, at 568 yards' distance, another specimen which was badly mutilated and its marking indistinct. The marking on the specimen of August 5, however, was unmistakable.

Although at one time or another during the period of the observations the wind was from other directions, the prevailing winds were west and southwest and these coincided with the days most favorable for the flight of the flies. The chief tendency, therefore, would be for a dispersal in a northeasterly direction. The double barrier intervening between the point of release and that of recovery undoubtedly retarded and even prevented dispersal in that direction, and consequently neutralized the effects of a favorable wind.

The fact that no appreciable number of marked flies were collected at the points of observation would indicate these were undoubtedly close to or slightly beyond the range of normal flight. The recovery recorded, however, indicates that even such distances under favorable circumstances are not beyond the possible limits of dispersal.

THE APPLE LEAF-CURLING MIDGE, A NEW PEST OF APPLES[1]

By W. D. Whitcomb, *Massachusetts Agricultural Experiment Station*

In 1928, the writer's attention was called to apple trees at Ipswich, Massachusetts, on which there were many rolled leaves containing small maggots. Adults reared from this material were later tentatively identified by Dr. E. P. Felt[2], Stamford, Connecticut, and by Dr. H. F. Barnes, Rothamsted, England, as *Dasyneura mali* Kieffer, this being, apparently, the first record of this species from North America.

Distribution—For three years this insect was observed on the trees where it was first found and was not reported elsewhere, but in 1932 it increased considerably in the originally infested orchard and was found in several other properties in the town of Ipswich.

An organized search in 1933 resulted in finding the midge in fifteen

[1]Contribution No. 182 of the Massachusetts Agricultural Experiment Station.
[2]Journal of Economic Entomology, Vol. 25, No. 4, August 1933, p. 932.

towns comprising an estimated area of about 1,000 square miles in northeastern Massachusetts and southeastern New Hampshire. This infested territory which includes some of the largest commercial orchards in New England is bounded on the south by Melrose and Winchester, Massachusetts, on the west by Chelmsford and Westford, Massachusetts, and on the north by Durham and Rye, New Hampshire. Many of the recently discovered infestations were well established, and there were rumors that rolled apple leaves had been seen for five years but no authentic records could be located.

DESCRIPTION.—The original description of *Dasyneura mali* was made by Kieffer in 1889 but it was not published until 1904 on page 345 of Annales Société Scientifique Bruxelles XXVIII. A translation from the French follows:

"*Imago*————. Of a flesh red; thorax reddish yellow; face, palpi and feet brownish; posterior border of eyes white; occiput, funicule of the antennae, three large bands occupying nearly all of mesonotum and large transverse bands on the back of the abdomen black, the last covered with scales of the same color; part of the chest, club of halteres and the mandibles dark. *Antennae of female* 0.60 mm. long composed of 2 + 13 joints; joints of the funicule cylindrical with three whorls of bristles and without distinct neck; the last two, on all of the individuals observed, completely fused and seem to form but a single joint nearly twice as long as any of the others, a little contracted in the middle and with 5 or 6 whorls of bristles. Those of the *male* (*antennae*) 1.10 mm. long, composed also of 2 + 13 joints; joints of the funicule like a short cylinder with three whorls of bristles of which the middle one is very long, the lower one, on the contrary, being short and almost fused; the tip is ovate; neck of the first short, that of the following one-half as long as the joint; toward the middle of the antennae the necks are longest composing three-fourths of the joint. *Wings of female* 1.50 mm. long, strongly iridescent; anterior margin covered with black scales; similar scales appearing on the first and second longitudinal veins, at the base of the third and at the extreme base of the posterior margin, also on the feet; the first vein is a little nearer to the margin than to the second; this one being slight curved at the base, partially removed from the wing extremity to its point of insertion; transverse vein oblique and well marked; the extremity of the wing is 0.85 mm. distant from the first vein, 0.08 mm. from the extremity of the second, 0.75 mm. from the fork of the third and 0.20 mm. from the end of the large branch of the fork. Pocket of the oviduct long and narrow. Size of female 1.50 mm.; male 1.40 mm.

Habits and larva. The larvae of this species are bright red and are found in colonies in the marginal rolls of leaves of *Pyrus malus* L. Pupation takes place in the ground. I have obtained the perfect insect on July 10 from larvae which entered the soil the preceding June 1."

The adults of the species found in New England are slightly larger but otherwise agree very closely with the original description. The larvae, however, are white to creamy white when immature, changing

to orange when mature, which does not correspond to Kieffer's "rouge vif" nor to Barnes[3] "red larvae".

RELATED SPECIES.—A closely related midge, *Dasyneura pyri* Bouchê, which curls the leaves of pears has been found in the Hudson Valley by Mundinger.[4] This midge attacks only pears even where apples are growing adjacent to infested pears, while in New England the apple-infesting species has not been found on pears which were surrounded by heavily infested apple trees. Similar conditions are reported from the British Isles and Dr. Barnes[3] states that although *Dasyneura mali* and *D. pyri* are nearly identical morphologically he has not been able to breed *D. pyri* on apple in the laboratory.

HOST PLANTS.—Apple is the only known host of *D. mali*. In New England there appeared to be a distinct preference among varieties but no variety which was exposed to infestation was entirely immune. The susceptibility of several leading apple varieties in two orchards was classified as follows:

TABLE 1. DEGREE OF INFESTATION

Variety	Ipswich, Mass.	Westford, Mass.
Baldwin	Moderate to severe	Severe
Delicious	Severe	Moderate
McIntosh	Severe	Moderate to severe
Gravenstein	———	Moderate to severe
Red Gravenstein	Moderate	———
Richard	Moderate	———
Starking	Moderate	———
Astrachan	Moderate	Slight
Yellow Transparent	———	Slight
Duchess	———	Slight
Wagener	Slight	Slight
Wealthy	Very slight	Very slight

INJURY.—Injury to the tree by the apple leaf-curling midge is confined to the foliage on terminal branches and watersprouts. The rolled leaves cease to function properly and fall prematurely so that the growth is slightly delayed and stunted. On young trees and scions this type of injury is very undesirable and may be compared to that caused by the rosy apple aphid or the green apple aphid. On large trees, two to six of the leaves on almost every terminal branch have been rolled by the first and second generation of the midge, giving a decided "blighted" appearance to the foliage. The owner of one infested orchard said: "My trees look as if they were neglected and I am ashamed to show visitors through them." On bearing trees an infestation by this midge has not noticeably reduced the size, color, or abundance of fruit. Water-

[3]Journal of the Southeastern Agricultural College, Wye, No. 28, 1931, pp. 170–177.
[4]Journal of Economic Entomology Vol. 25, No. 3, June 1932, p. 728.

sprouts, particularly those attacked by the later generations, shed the rolled leaves soon after the larvae have matured in them but this growth is seldom considered to have much value to the tree. Wild or neglected

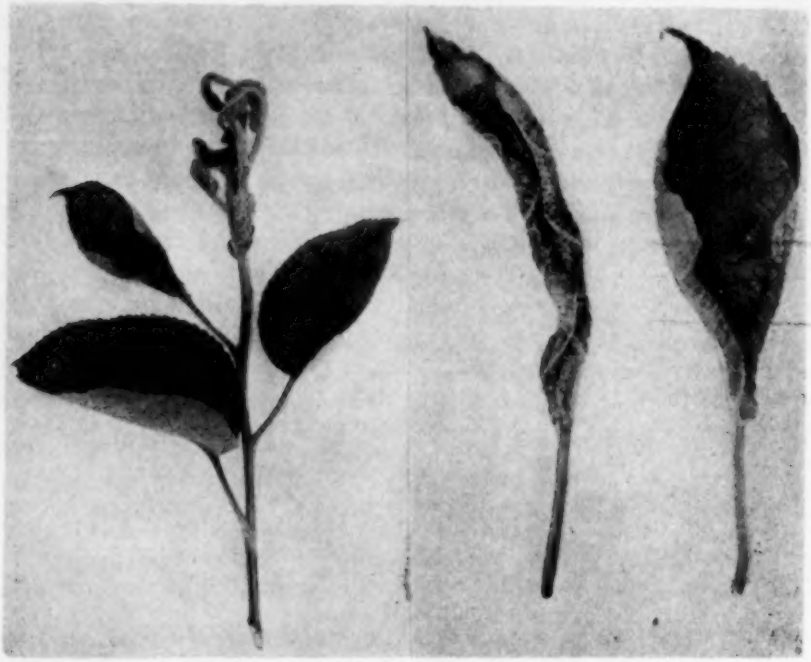


FIG. 15.—Terminal twig showing leaves rolled by apple leaf-curling midge; at right older leaves rolled by this midge.

trees which make little or no new growth are seldom attacked even when adjacent to heavily infested trees.

LIFE HISTORY.—The eggs are light reddish brown in color and elliptical in shape, being about five times as long as wide. They are laid irregularly in groups on the margin or upper side of unfolding leaves, apparently relying on the pubescence of the leaf to keep them from falling. The developing embryo is easily seen within the egg. The incubation period is 3 to 5 days.

The tiny larvae are white or creamy white until the last instar when they acquire a bright orange color. They live entirely within the tube formed by the rolled leaf and cannot survive bright sunshine for any length of time. The result of feeding by the larvae is very inconspicuous, being indicated only by the appearance of small red blisters which later

turn black. No actual destruction of the epidermis or pubescent hairs of the leaf has been observed. The leaves are rolled from the underside upward toward the midvein and parallel to it.

Usually the infested leaves are rolled from both margins toward the midvein but occasionally only one margin is rolled. The feeding of the larvae apparently causes the leaf to roll inward, or, rather, prevents the opening leaf from unfolding. When larvae were transferred to newly opened leaves they made no attempt to roll them and died in 24 hours, indicating that the actual rolling is the result of growth by the leaf and that any physical action by the maggot determined the direction in which the leaf would grow or roll rather than actually causing the roll. The number of maggots per leaf in 10 typical leaves varied from 9 to 30 and averaged 17, but one heavily infested leaf was found to contain 131 larvae. The larval feeding period is approximately 20 days. Upon reaching maturity most of the maggots fall to the ground, leaving by the ends of the rolled leaves rather than eating through the side. Occasionally, maggots have pupated in the leaves but these cases appear to be accidental.

Pupation takes place in a tough, white, silken cocoon which is spun just beneath the surface of the ground, or among loose pebbles of earth. When the midge is ready to emerge the pupa works its way about three-fourths out so that the empty pupa case is left protruding from the cocoon after emergence. Reared specimens required 13 to 18 days for pupal development and those of the first generation transformed in the least time.

The adult midges are rather inconspicuous because of their small size,—the bodies being 2–2.5 mm. long and the wings 2 mm. in length. The females are most easily distinguished by a larger abdomen and the presence of the ovipositor as well as shorter antennae. They are quite active but lived only three or four days in rearing cages. The apparently sudden appearance of them at widely separated places indicates that they are reasonably strong fliers or, at least, can survive strong winds which blow them long distances. The rate of oviposition is unknown but presumably is quite high. Several midges have been observed ovipositing on one leaf and apparently a female midge will oviposit on several leaves. Only leaves which are about two-thirds unfolded or less are attractive to the midges for oviposition and in early June, during rapid foliage growth, the leaves are in a satisfactory condition only about two days.

Seasonal History and Number of Generations.—There are apparently four generations annually in Massachusetts, the last two

varying in numbers because of their dependence on watersprouts and both generally being rather small. In 1933 rolled leaves containing small maggots were first observed on May 18 but they were not abundant until June 6, indicating that the principal oviposition period of the first generation was about June 1, approximately 10 days after full bloom of apples. Maggots of the second generation were abundant in the rolled leaves from July 15 to August 1, being about as numerous as those of the first generation. By August 25 newly rolled leaves on watersprouts were very noticeable, these being infested by maggots of the third generation. During the McIntosh harvest in late September rolled leaves were found occasionally containing newly hatched maggots which might have been late developing individuals of the third generation but presumably constituted a partial fourth generation.

Complete rearing records throughout the season have not been secured. The seasonal history diagram has been prepared from observations during frequent visits to infested orchards and represents the approximate periods of development of this midge in the vicinity of Ipswich, Massachusetts.

SEASONAL HISTORY *Dasyneura mali* KIEFFER

Based on Orchard Observations at Ipswich, Mass., 1933.

	Egg	Larva	Pupa	Adult
Overwintering Generation..				May 15–June 5
First generation.....	May 16–June 8	May 20–June 25	June 10–July 15	June 25–July 10
Second generation.....	June 26–July 13	June 30–Aug. 1	July 20–Aug. 20	Aug. 10–Aug. 25
Third generation.....	Aug. 11–Aug. 28	Aug. 15–Sept. 1	Sept. 5–Sept. 20	Sept. 15–Sept. 25
Fourth generation.....	Sept. 16–Sept. 30	Sept. 20–Oct. 5	Not observed	Not observed

NATURAL ENEMIES.—Early in the season little evidence of natural enemies of this midge was observed but during September a tiny Anthocorid bug, probably *Orius* (*Triphleps*) *insidiosa* Say was often observed attacking the larvae in the rolled leaves and a few specimens of an undetermined parasitic hymenopteron were reared. In the orchard the presence of these parasites is usually indicated by emergence holes through the side of the rolled leaves. Similar parasitic and predaceous insects have been found in New York by Mundinger (personal correspondence) attacking the pear leaf-curling midge so effectively that the pest was much less abundant in 1933 than previously.

CONTROL MEASURES.—It is quite apparent that the usual spray schedule has little or no effect on this midge since well sprayed trees

were heavily infested and numerous midges were found living in curled leaves having a heavy deposit of spray material within the rolls.

Experiments to control this pest are not sufficiently advanced to report but it appears that summer pruning, cultivation, and soil insecticides can be used to supplement the work of natural enemies and prevent extensive damage.

STUDIES ON CONTROL OF THE WHITE APPLE LEAFHOPPER[1] IN CONNECTICUT

By PHILIP GARMAN, *Agricultural Experiment Station, New Haven*

Owing to unusual abundance of leafhoppers in Connecticut apple orchards in 1929 and 1930, it was necessary to investigate the life history and methods of control of this insect. Since the periods of heavy infestation, however, there has been a conspicuous decline in numbers until at the present time it is doubtful whether control measures are advisable. Our work with the white apple leafhopper is by no means complete, but in view of its rapidly decreasing numbers, and the fact that it may not reach the epidemic stage again for a number of years it is thought advisable to present what data we have obtained thus far.

The seasonal life-history in Connecticut has been discussed in Bulletin 349 pp. 429–30 of The Connecticut Agricultural Experiment Station. We have checked the data in two central Connecticut orchards this year and completed that portion of the chart (Fig. 16) dealing with egg deposition of the second generation.

Control is not difficult if thoroughness of application is considered worth while by the orchardist. The main disputes seem to arise regarding the advantage of spring over fall applications. In severe infestations it is quite probable that sprays at both periods are needed. If there is much chance for migration to the orchard from outside trees, there will be two danger periods regardless of whether early contact sprays have been applied. Other questions frequently asked by growers are (1) when is it worth while to spray for the insect, and (2) if only one application is needed should it be made in spring or fall. This year, counts of leafhopper populations indicated that less than 50 nymphs per 100 leaves produced a total population which might be disregarded. For the second brood this year, however, 150 per 100 leaves was not enough to be considered a menace though apparently pretty close to the border. In 1932, 250 per 100 leaves gave enough to cause considerable damage.

[1] *Typhlocyba pomaria* McAtee.

Two hundred per 100 leaves may therefore be regarded as near the limit for the second generation which can be safely allowed to develop. As to when is the best time for one application assuming only one is needed, it would probably be safer and more scientific to base control measures on population counts at the height of nymphal emergence rather than follow a spray schedule blindly. As to which period affords

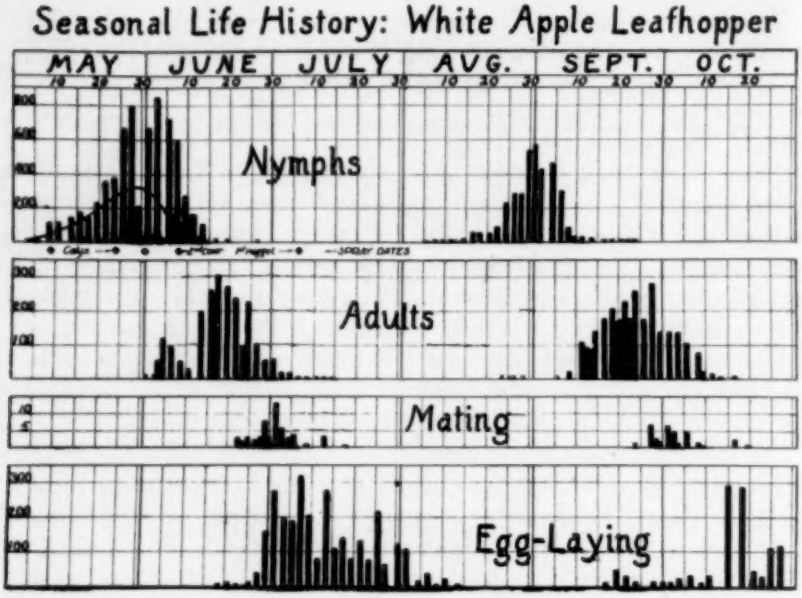


FIG. 16.—"Nymphs" indicates periods of emergence obtained by frequent examination of marked branches in the orchard. "Adults" indicates periods of adult emergence from the nymphal stage. "Mating" shows periods for this activity based on uniform field counts of short duration each day. "Egg-laying" periods were obtained from leafhoppers confined in cloth insectary and field cages. Data from which chart was made obtained at Mt. Carmel in 1932 and 1933, except that indicated by x's which were observations in other orchards. Chart constructed by Mr. J. F. Townsend.

the most effective control, it is believed that fall applications of contact sprays are somewhat more effective than the same materials applied in spring combined with fungicides and stomach poisons. Our observations indicate that there is little or no emergence of nymphs after applications in early September and the effects of the sprays are frequently to be observed the following year in reduced leafhopper populations. The reason for lowered effectiveness of spring applications is due

partly, I think, to destruction by combination sprays of parasites and enemies which are of considerable benefit. It has been argued that spring applications for hopper control are useless in Connecticut on this account, but there is reason to believe that parasites are destroyed by early sulfur sprays regardless of whether they contain nicotine. When the application is made, as long as leafhopper enemies are killed, why not kill the leafhoppers too?

The main objections to fall applications, and they are serious ones, lie in the fact that the trees are frequently difficult to spray thoroughly without knocking off the fruit and in the fact that the orchardist may be busy harvesting early fruit or peaches at the time when sprays are needed. However, applications for leafhoppers have been made in commercial orchards at both periods with rather better success in the later period although there have also been failures here as well as successes.

We have not experimented extensively with controls for adults, but there seems to be far less difficulty in controlling nymphs than adults. In the nymphal stage, they are easily killed by a number of sprays including pyrethrum products, nicotine sulfate, free nicotine, and anabasine sulfate. It is probable that others will be found to be equally effective. The selection of any one of them for spring use depends on cost and compatibility and at present we believe that nicotine sulfate, free nicotine, and anabasine sulfate are the most promising for this period.

For late season sprays there are a number of possibilities. Pyrethrum soaps and similar preparations appear to be equally as effective as nicotine sulfate, the only consideration being relative cost per gallon of spray. Here the problem of soaps, oils, and activators becomes important, especially with reduced dosages. In regard to the use of soap or activators with leafhopper sprays we do not believe that it is advisable to recommend too great a dilution of the insecticide. If on the other hand a dilution of one to 1,600 is being used with oil, activator, or spreader, the reduction in cost to the grower is not usually great because of the expense of the oil, or other material which takes the place of that part of the insecticide which is omitted. Commercial growers have applied oils and contact sprays successfully. Anything leaving a residue should be avoided for control of leafhoppers at this period.

Besides nicotine sulfate, both anabasine sulfate and free nicotine have given satisfactory kills at a dilution of one to 800 without the addition of soap or activator. The following tests include those made in 1932 and 1933, Table 1. The costs are based on 1933 prices obtained

from the company manufacturing the insecticide and are presumably retail prices to commercial growers. The price per 100 gallons is based on 5-gallon lots or the nearest unit of quotation. All products used were commercial preparations. The experiments in all cases were field experiments on bearing trees and the per cent reduction was figured on counts of leafhopper nymphs made immediately before and immediately after the spray was applied. Commercial orchard power sprayers were used in all experiments.

CONTROL OF SECOND GENERATION NYMPHS OF THE WHITE APPLE LEAFHOPPER

Materials used		Per cent reduction of leafhopper nymphs	Cost per 100 gallons diluted spray
Nicotine sulfate	1 pint		
Water	100 gals.	89.4, 90.1, 96.1	.88
Nicotine sulfate	¾ pint		
Soap (flake)	3 lbs.		
Water	100 gals.	83.8	1.03
Nicotine sulfate	1 pint		
Soap (flake)	3 lbs.		
Water	100 gals.	88.1	1.24
Nicotine sulfate	1 pint		
Coc. oil soap (40%)	2 quarts		
Water	100 gals.	99.3	1.30
Check—no treatment		10.4	——
Free nicotine	1 pint		
Water	100 gals.	99.8	1.07
Anabasine sulfate	1 pint		
Water	100 gals.	98.5	.70
Pyrethrum extract in penetrol	1 pint		
Penetrol	1 quart		
Water	100 gals.	95.2	.71
Pyrethrum soap	6 lbs.		
Water	100 gals.	98.8	3.00
Check—no treatment		00.0	—

OBSERVATIONS ON THE HABITS AND CONTROL OF *GLOSSONOTUS CRATAEGI* (MEMBRACIDAE), ON PLUM AND APPLES[1]

By RAY HUTSON, *Section of Entomology, Michigan State College, East Lansing, Michigan*

Glossonotus crataegi[2] first described in 1851 by Fitch (1)[3], is, when adult, a strikingly marked tree-hopper about eight mm. long. The ground color is deep brown with areas of chestnut red; whitish-yellow markings appear on pronotum. The nymphs markedly resemble those of other tree-hoppers found upon fruit trees. This Membracid has been reported from the north and northeastern states as far west as Nebraska. The oldest specimens in the collection at Michigan State College bear the date of 1881. Since that time it has been collected from time to time, but prior to 1931 no known account records it in any numbers in Michigan. Records from other sources report it as rare to common. Funkhouser (2) notes as its host-plants quince, crabapple, hawthorn. It has been noted as a pest, although not a serious one, on quince. Previous observers on the life-history and habits of this tree-hopper agree that the insect overwinters in the egg-stage, and that its eggs are inserted in the bark of the host-plant through a single opening, and that it is primarily a one-host creature.

OBSERVATIONS.—Our observations upon this insect during the seasons of 1931, 1932, and 1933 confirm these findings, and in addition establish that the egg punctures are most numerous on one or two year old wood, although other observations confirmed by cage experiments indicate that a few eggs are laid upon both older and younger tissues. It has also been noted that there is little tendency for egg deposition in particular locations, i.e., in relation to buds, lenticels, axils, or crotches. Hatching occurs during late May and early June. The egg-laying punctures apparently do not cause the marked scarification of the twigs and smaller branches, commonly observed with Stictocephala, Ceresa, and other tree-hoppers.

G. crataegi nymphs were observed feeding on the stems of plums in late June, 1931, and causing a severe drop. In feeding, the insects assume a position on the stem with the head downward. The proboscis is then inserted into the tissues and feeding continued for a varying

[1]Authorized for publication as Journal article No. 174 S. Michigan State College Experiment Station.

[2]Determination verified by Dr. W. D. Funkhouser.

[3]Figures in parenthesis refer to references cited.

period. As many as eighteen nymphs were observed on the stem of a single plum, although this was considerably more than the average number of around five insects per plum. There is, in late June, an apparent tendency to concentrate upon the fruit noted. When feeding in large numbers the nymphs excreted quantities of honeydew. The immediate results of the feeding were indefinite watery areas. Within a day or two the tissue in the watery areas dries out, interfering with the water relationships of the fruit, an abscission layer is formed and plums drop. In case the plums did not drop, a small corky scar about the size of a pin-head developed. The number of punctures necessary to cause the dropping was variable, although at a later period as many as five scars might be present on the stem of a plum which remained upon the tree. Few nymphs were seen on water sprouts on plum. The effects of feeding by the nymphs of this tree-hopper on apple are not as definitely established as on plums. During the season of 1933 observations on the feeding of *G. crataegi* on apple were made in an orchard where these insects were extremely numerous. Both nymphs and adults are extremely gregarious, and it was not at all uncommon to find as many as 150 on a branch the size of a lead pencil and two feet long. Under such conditions copious quantities of honeydew were excreted, fouling everything about and beneath the branch on which the tree-hoppers were found. The leaves on such branches assumed a sickly, yellow color, and in many cases began dropping. It was possible under these circumstances to stand at a distance from the orchard and pick out the infested branches by their color. The insects occasionally attacked water sprouts on apple. There was an extremely light crop upon the orchard in which these observations were made, consequently, the effect on the fruit could not be noted.

CONTROL.—The outbreak of *G. crataegi* on plum occurred in a plum orchard which had received for the three preceding years a four per cent dormant spray of one of the commercial oils for the control of San Jose scale and European red mite. The apple orchard had also been regularly sprayed with a home-made emulsion containing three per cent lubricating oil.

From these facts it is apparent that the dormant oil sprays do not constitute a sufficient control measure against this insect (3).

Nymphal stages of this pest are very susceptible to contact sprays. A spray consisting of one gallon of summer oil emulsion plus one-half pint of nicotine sulphate in 100 gallons of spray completely controlled them, as did also a spray consisting of one-half pint nicotine sulphate plus one-half gallon of penetrol in 100 gallons of spray. Each treatment

gave approximately 100 per cent control. It was almost impossible to find nymphs after a thorough spraying with these materials. Various nicotine and pyrethrum dusts did not prove effective against the nymphs.

The adults are extremely resistant. The same oil sprays which killed the nymphs had practically no effect on them. Nicotine derris, and pyrethrum dusts had no effect upon them.

REFERENCES CITED

1. 1851. FITCH, ASA.—Cat. Insects of N. Y. P. 52.
2. 1917. FUNKHOUSER, W. D.—Biology of the Membracidae of the Cayuga Lake Basin. Cornell Memoir 11.
3. 1930. YOTHERS, M.A.—Tree-hoppers and Their Control in the Orchards of the Pacific Northwest. U. S. D. A. Circular Bulletin 106.

EXPERIMENTS WITH KEROSENE EMULSIONS AGAINST THE APPLE CURCULIO (*TACHYPTERELLUS QUADRIGIBBUS* SAY)

By O. H. HAMMER, *N. Y. State Agricultural Experiment Station, Geneva, N. Y.*

There is considerable evidence that the stomach poisons commonly used for spraying apple trees do not give satisfactory control of the apple curculio. Some of the common contact insecticides have been tested and they appear to be even less effective against this insect. It has been reported that the destruction of infested June drops is an effective method of reducing the beetle population in a planting. The two chief ways in which this destruction is accomplished is by the use of hogs to eat the drops and by collecting the drops by hand. While either of these methods may be practical under some conditions, under others they become impractical. A method is being sought whereby the insect can be destroyed and the fruits allowed to remain where they fall. Tests were made with materials applied to both the adults after they had emerged from the fruits and to the infested fruits. Of the materials used in these tests kerosene emulsions at various concentrations gave the most striking results. In these tests kerosene and gasoline emulsions and these two materials in combination with paradichlorobenzene or naphthalene were used. The naphthalene and paradichlorobenzene were incorporated into the kerosene and gasoline by first dissolving them in the two latter materials until a saturated solution was obtained. In making the emulsions a finely divided clay was used as the emulsifying agent, it being used at the rate of 1 lb. per gallon of kerosene or gasoline. A few tests were also made with pine oil emulsions.

TESTS WITH BEETLES.—The beetles used in this test were obtained from emergence cages in the orchard. The materials were sprayed directly on the beetles after they had been placed on the ground. The emulsions were applied with a knapsack sprayer and just enough of the material was used to cover the insects well. Immediately after the treatment a hardware cloth cage was placed over the beetles to prevent their escape. The data presented in Table 1. were obtained 24 hrs. after the treatment was made. Observations at periods of more than twenty-four hours after the treatment showed that the beetles did not recover, and in some instances the kill was even greater than that reported at the end of 24 hours. Usually however, the kill is very quick. Results of the tests are presented in Table 1.

TABLE 1. EXPERIMENTS WITH BEETLES

Treatment	Number of treatments	Total number beetles used	Average per cent mortality
50 per cent kerosene	1	10	100
50 per cent gasoline	2	20	100
50 per cent kerosene and P. D. B.	1	10	100
50 per cent gasoline and P. D. B.	2	20	100
50 per cent kerosene and naphthalene	1	10	100
50 per cent gasoline and naphthalene	2	20	95
25 per cent kerosene	3	40	92.5
15 per cent kerosene	1	20	90
25 per cent kerosene and naphthalene	3	40	85
25 per cent kerosene and P. D. B.	3	40	77.5
15 per cent kerosene and P. D. B.	1	20	75
15 per cent kerosene and naphthalene	1	20	40
25 per cent gasoline and P. D. B.	2	20	20
5 per cent pine oil No. 5	1	20	20
25 per cent gasoline and naphthalene	2	20	10
25 per cent gasoline	2	20	0.0
Control	4	60	0.0

TESTS WITH INFESTED APPLES.—During the June drop a large number of fruits was collected from infested plantings. Collections were made at four different times during this period, and after each collection various treatments were made. Some of the treatments were repeated two or more times while others were made only once. In each case all of the apples used for any one experiment were of the same source and theoretically equally infested. The materials used in making the treatments were the same as those used in treating the beetles except that gasoline was not used. The infested fruits were placed on the ground in a layer so that at no point were fruits lying on top of each other. They were arranged in groups of equal numbers and then treated by spraying the emulsion on them with a knapsack sprayer. Enough of the material was used to give thoro coverage, but excess

wetting was avoided. A control lot of fruits was maintained in each instance. After treatment the fruits were covered with cheese cloth cages. Daily emergence records were taken. The results of this experiment are given in Table 2.

TABLE 2. EXPERIMENTS WITH INFESTED FRUITS

Treatment	Number of fruits used	Average per cent fruits infested	Total number beetles emerging	Average per cent killed over control
50 per cent kerosene	10780	4.82	0	100
50 per cent kerosene and naphthalene	280	41.2	0	100
50 per cent kerosene and P. D. B	80	32.92	0	100
25 per cent kerosene	11280	4.2	0	100
25 per cent kerosene and P. D. B	80	32.92	0	100
25 per cent kerosene and naphthalene	780	22.35	1	99.42
10 per cent kerosene and naphthalene	280	41.2	9	92.58
10 per cent kerosene	280	41.2	14	87.35
15 per cent kerosene	1000	11.8	25	78.81
10 per cent kerosene and P. D. B	80	32.92	8	69.62
15 per cent kerosene and naphthalene	1000	11.8	40	66.1
10 per cent pine oil No. 5	200	44.5	51	41.39
5 per cent pine oil No. 5	200	44.5	71	18.39
Control	6940	5.84	404	0.00

The results presented in the tables indicate that 50 and 25 per cent kerosene emulsions gave a high degree of kill. Concentrations of less than 25 per cent kerosene gave varying degrees of kill. It is probable that these lower concentrations can not be depended upon for a consistently high kill. The results obtained in these tests seem to indicate that naphthalene and paradichlorobenzene do not add materially to the effectiveness of either kerosene or gasoline, and in certain instances it appears that they even lowered the efficiency of the emulsions. Apparently the pine oil at concentrations used in these tests have very little effect on the insect.

Several tests have been made in an effort to determine the effects of the kerosene emulsions on the trees when applied to the ground under them. So far as could be determined the trees suffered no ill effects from the treatments when the emulsion was used at the rate of 15–20 gallons per tree. The grass above the soil surface and any apple foliage that chanced to be in the way was killed when the emulsions were sprayed directly on them. The grass roots however, seemed to be little if at all affected by the treatments, and new blades of grass grew out immediately. The question of safety to the trees is not yet completely settled.

PHOTOTROPIC RESPONSES OF THE CODLING MOTH[1]

By P. J. PARROTT and DONALD L. COLLINS, *New York State Agricultural Experiment Station, Geneva, N. Y.*

One of the phases of codling moth (*Carpocapsa pomonella* Linn.) activity which is being studied at the New York State Agricultural Experiment Station is that of the phototropic responses of the species and the possible utilization of this tropism in reducing the moth population by means of light traps. The experiments are being conducted in the Rome orchard on the Station grounds. The planting is about 35 years old, and is divided into plats as shown in Figure 17. In the lighted section were 40 trees equipped with electrocutor type light traps, one in each tree. Bait pails were installed in 13 of these trees and in 4 additional trees outside of the lighted area. 75-watt type A bulbs were used as light sources in the light traps, and a mixture of diamalt and water was used as the attrahent in the bait pails. The light traps and bait pails were examined every morning for codling moths from the early part of May until the middle of October.

Emergence of the first brood moths was recorded from daily observations of five emergence cages in which overwintering caterpillars had been placed. As the moths made their appearance they were transferred to oviposition cages for further observation. During June and early July all of the trees were banded to entrap the caterpillars arising from the first brood moths. The bands were removed and examined every week and the larvae were placed in 80 cages, one cage being located in each lighted tree and one in each of an equal number of unlighted trees. Into each cage there were placed only the caterpillars from the tree in which it was located. The second brood emergence was recorded from daily counts of the moths emerging in these cages, and the moths were released into the orchard at the cages as soon as they had been counted. A total of nearly 23,000 caterpillars were placed in the cages, from which in 1933, 1,262 moths emerged. Of the remaining caterpillars some are undoubtedly accounted for by death due to various causes, but the majority have probably hibernated as the overwintering generation, so that the complete record cannot be obtained until the summer of 1934.

A continuous thermograph record was kept in order to facilitate the determination of correlations between temperature and the activities of the moths as revealed by the emergence cages, light traps, and bait pails.

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 32, Jan. 29, 1934.

LIGHT TRAP AND BAIT PAIL CATCHES AND THEIR RELATION TO TEMPERATURE.—The relationship of these factors is brought out in Figure 18. The catches are plotted on the basis of averages per trap in order to allow for the difference in number of bait pails and number of light traps. It can be seen that in general there is a close agreement in the daily rise and fall of the three curves, especially during the period of flight of the second brood, when larger numbers of moths were obtained.

The light traps captured a total of 8,982 moths, the first being cap-

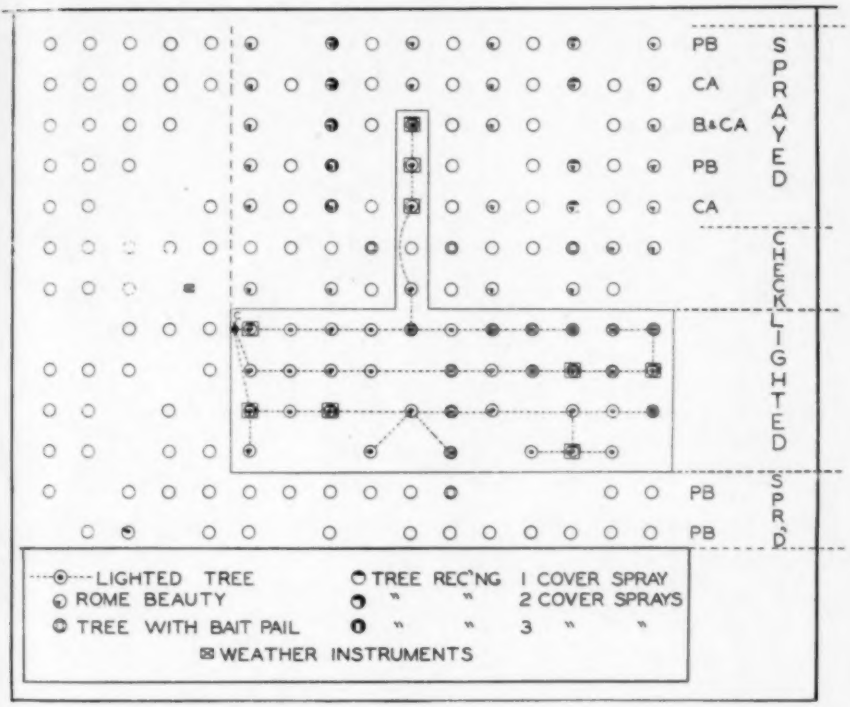


FIG. 17.—Plan of codling moth experiments in Rome Beauty orchard. The spray materials used on different rows are indicated by letters at the right of the row. PB for lead arsenate, CA for calcium arsenate, B & CA for bordeaux and calcium arsenate. C designates the location of the photronic cell and thermostat controls of the lights. A square around a circle indicates a lighted tree that received spray treatments also. Rome Beauty trees which received combinations of treatments are designated by combinations of the appropriate key marks. The lines composed of short dashes indicate the wiring plan of the lighted trees. The line of long dashes and the left and lower boundaries of the lighted area represent the dividing line between the experimental plats and the remainder of the orchard.

tured on May 24 and the last on October 11. The bait pails captured 2,494 moths, the first captures occurring on May 25 and the last on September 17. The light trap seasonal average per trap was 225 moths, and the bait pail average per pail was 146. The manner in which these averages were distributed from day to day is shown in Figure 18. That

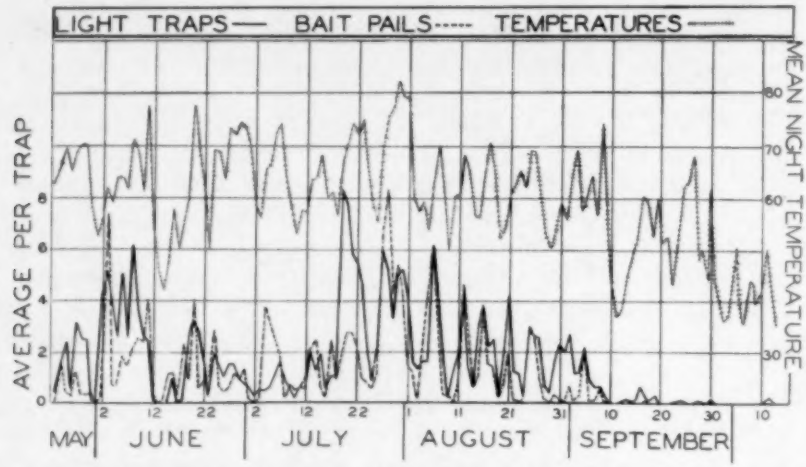


FIG. 18.—Codling moth light trap and bait pail catches. Nightly counts, with mean night temperatures (the mean of the temperatures in degrees F from 7:00 P. M. to 4:00 A. M. inclusive, taken at hourly intervals). Plotted on the basis of averages per trap.

low temperatures inhibited the activities of the moths is evident from the reduced catches in both light traps and bait pails on cool nights.

There were three distinct flight periods of the moth—two periods of normal flight, occurring during the morning and evening twilight respectively, and the period of flight at night in response to the stimulus of the artificial lights. The bait exerted its attractive power, as far as was observed, only during the brief periods of normal intense activity, whereas the lights attracted moths all night under favorable conditions. In other words, the positive phototropic response was in evidence over a longer period of time each night than the positive chemotropic response. The proportionately larger light trap catches on certain favorable nights may possibly have been due in part to the longer period of active sensitivity of the moths to lights.

Temperature and other conditions might, and sometimes did, change from favorable for flight during the period of positive chemotropic response to unfavorable by the time the phototropic response would

ordinarily be manifested; or conditions might change from unfavorable during the first period to favorable during the second, so that the relationship of points on the curve should not be expected always to be constant.

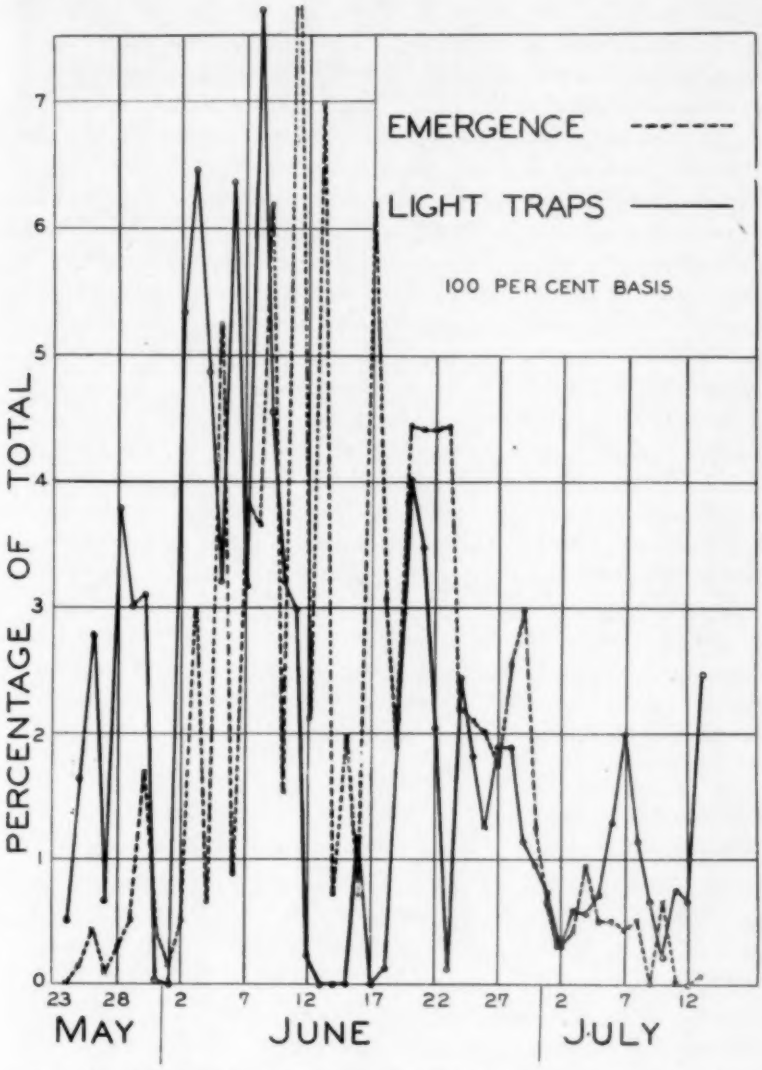


FIG. 19.—Codling moth emergence and light trap records, *first brood*. Plotted on basis of percentages of totals. (100 per cent basis). Daily records.

It should be noted, with respect to the bait pail catches, that the bait was changed regularly in the different pails in rotation, so that a certain number of pails always had fresh bait, or bait at the proper stage in fermentation. Presumably there were few times when all of the pails could be assumed to be functioning at maximum effectiveness. Intense heat caused too rapid evaporation, and certain other conditions induced souring of the bait. Moreover, high winds caused more or less loss of material, and heavy rains caused dilution and overflow. These adverse factors undoubtedly account to some extent for the smaller catches in the bait pails as compared with the light traps. However, even tho the light traps appear to be more consistently reliable as indicators of codling moth activity than the bait pails, the catches by either means seem to be satisfactory guides in forecasting spray dates. Moreover, in view of the large catches of females it would appear that there should be a measurable diminution of the moth population which might possibly be reflected in the condition of the fruit with respect to codling moth injury.

Light Trap Catches and Emergence.—Since the light trap record was obtained from a larger number of traps than the bait pail record, the data from the light traps are the more favorable as a basis for comparison with the emergence records. Moreover, the light trap catches began earlier and continued later in the season than the bait pail catches. For convenience in comparing the gradual rise and decline in the numbers of the two broods as indicated by the light trap catches and by the emergence, the data have been reduced to percentages of total catch and percentages of total emergence for each brood, respectively. The figures obtained have been plotted on this basis in Figures 19 and 20. The totals upon which these percentages are based are as follows:

	First Brood	Second Brood	Total
Emergence from cages	1,373	1,262	2,635
Light trap catches	3,190	5,792	8,982

Since the first moths in the second brood cages emerged on July 14, this date is arbitrarily taken as the beginning of the activity of the second brood moths, altho there undoubtedly were several days when moths of both broods were in flight at the same time. If the curves were smoothed a general coincidental rise and fall of both would be evident when the entire season is considered. It is apparent at once, however, that the actual points on the curves do not coincide. The light trap catches began on the day before the first moths emerged in the cages, and for a period of two weeks continued to be higher, with large catches of moths

occurring from one to two days earlier than days of correspondingly high emergence as indicated by the cage records. The peak of emergence in the cages occurred three days later than the largest light trap catch for the first brood, on June 11, and was followed by several days of

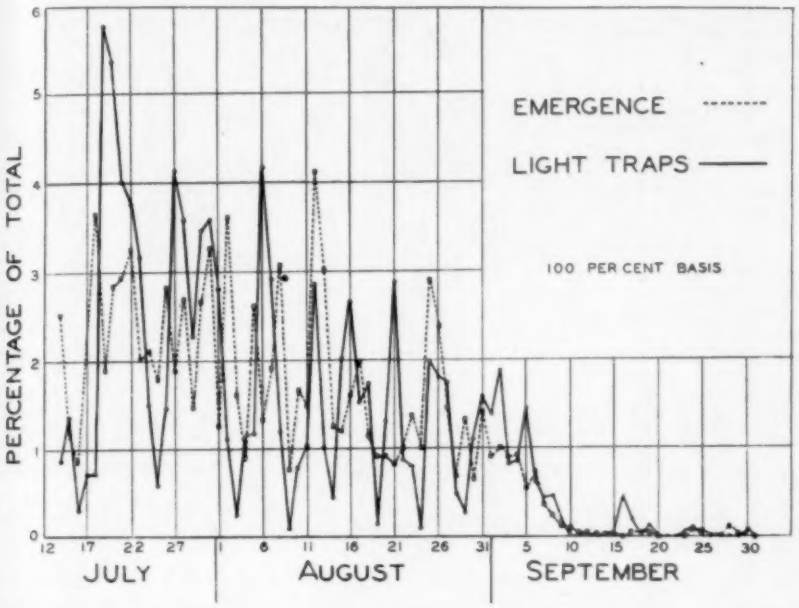


FIG. 20.—Codling moth emergence and light trap records, *second brood*. Plotted on basis of percentages of totals. (100 per cent basis). Daily records.

high rate of emergence; at the same time the light trap catches were diminishing. A similar condition obtained in the second brood, altho not quite so conspicuously. A logical explanation of these facts is that the emergence in the cages did not keep pace with the normal emergence in the orchard as a whole; that, due to altered conditions, the development of the pupae in the cages was delayed, and slower than the development of pupae under normal orchard conditions.

The method of taking the data on second brood emergence has already been mentioned. Each Rome Beauty tree in the orchard had its own emergence cage into which caterpillars from that tree only were placed, and all moths emerging in these cages were liberated on the day of emergence. The records of liberations make it possible to state definitely for any given night that a certain number of moths were known to be present in the orchard and subject to entrapping; in other words, each

day's minimum known population was established. Had there been no other caterpillars in the orchard, and no place for pupation other than the bands, the moths liberated from the individual cages would have made up the entire codling moth population. Naturally, however, these conditions did not obtain. Indeed, a comparison of the actual

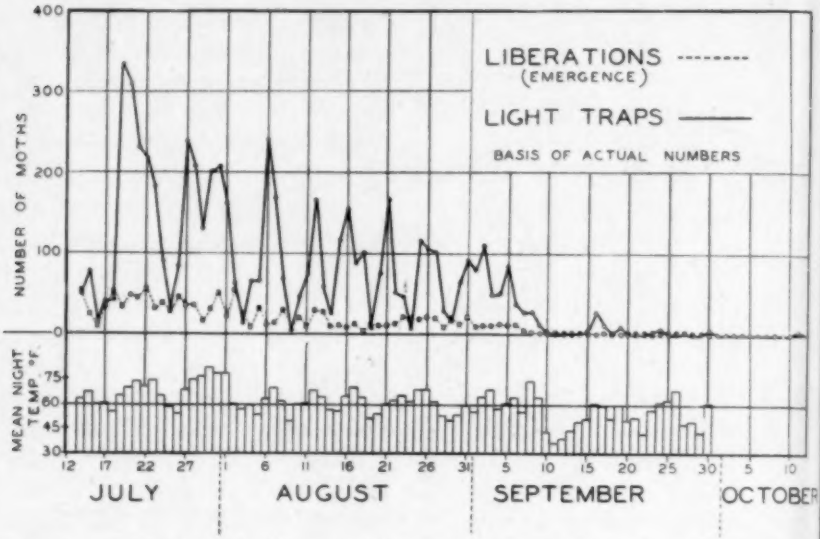


FIG. 21.—Second brood codling moth liberations (emergence) in the lighted area compared with the light trap catches. Plotted on the basis of actual numbers. Daily records, with mean night temperatures in degrees F.

emergence in the lighted area and actual light trap catches, as is shown in Figure 21, shows that there were many more moths captured in the lighted area than were recorded as having been liberated. Altho usually the trap catches were much greater than the known population, it can be noted from the chart that there were several nights when fewer moths were captured than were known to be present. Every such night was found to be a night of predominantly low temperatures or a night when the temperature descended to a comparatively low point.

RATIO OF SEXES IN THE CATCHES.—Figure 22 indicates the percentages of males and females in the catches of the light traps and bait pails. Of the 8,982 codling moths captured in the light traps, 8,059 were of known sex, the remaining specimens having been too badly burned to permit positive sex identification. Of these 8,059 moths, 3,885 or 43.2 per cent were females. Of the 2,494 moths captured in bait pails, 2,478 were of known sex. Of these 1,748 or 70.5 per cent were females.

The light traps captured an average of 97 females per trap, and the bait pails 102 females per pail, a difference of 5 specimens on the total average basis.

The higher average of females in the bait pails is possibly due to the fact that three of the bait pails were located in the old check section in

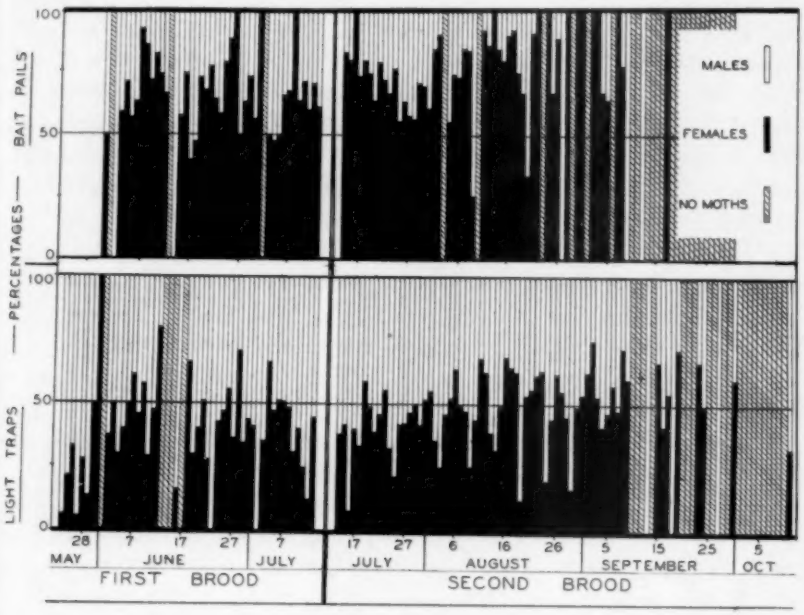


FIG. 22.—Percentages of male and female codling moths in light trap and bait pail catches. Daily records plotted on basis of percentage of total catch for each day. A bar which is black for its entire length indicates that all the moths captured that day were females; a bar which is entirely white indicates that the catch consisted entirely of males. When no moths were captured the bar for that day is cross-hatched.

trees that were very highly infested with codling moth. These three pails captured more moths than the other 14 pails together, so that the comparatively large number of moths captured in these pails might outweigh in the calculations the figures from the more normally located pails.

In the 13 trees which had both light traps and bait pails the average number of females per light trap was 105, while the average number per bait pail was 57. It would seem that where the bait pails and light traps competed directly in the same territory on an equal basis the light traps captured more females as well as more specimens.

Releases and recoveries of marked moths showed that virgin females were sometimes captured in the light traps on the night of the day of liberation.

DISTRIBUTION OF MOTHS IN ORCHARD AS INDICATED BY LIGHT TRAPS.—Comparisons of the numbers of moths captured in the several light traps indicated that there was a fairly even distribution of the codling moth population thruout the lighted area. There were 8 traps which captured 300 to 375 codling moths each; 15 traps which captured between 200 and 300; 13 traps which captured from 100 to 200, and 4 which captured less than 100 moths. The large and small catches were so distributed thruout the plat that by this criterion moths could not be said to have been more abundant in any one section of the planting than in another.

There was a general tendency for the catches to be smaller in the smaller trees and trees bearing a small crop of fruit, altho there were exceptions in the case of certain marginal trees. The larger catches occurred in traps located in trees in the outside rows of the plat, the largest catch of all occurring in the trap in the end tree of the row of lighted trees which projected into the unlighted area.

There is evidence from releases and recoveries of marked specimens that the moths migrated considerably within the lighted area and also from the unlighted sections to the center of the lighted plat, not always to the marginal trees. Whether, therefore, the larger catches in marginal traps are indications of concentration of moths from within the lighted area or should be construed as indicating a drift from without is uncertain. That the attraction of more moths to certain traps than to others did not necessarily result in higher infestation of the trees concerned was indicated by the counts of caterpillars under the bands.

SUMMARY.—Codling moth activity as indicated by light trap and bait pail catches was strongly influenced by temperature, a temperature below 60°F generally inhibiting flight. Other adverse weather conditions affected the bait pails to a greater degree than the light traps since high winds caused loss of material from the pails, and heavy rains caused dilution and overflow, while the extremely hot weather of the past season caused too rapid evaporation, and other conditions induced souring of the bait.

The relative positions in the seasonal distribution of high points in trap catches, and high points in emergence as judged by emergence cage records indicate that emergence in the orchard begins earlier and proceeds to a climax sooner than emergence in the cages under the conditions described.

Data from liberations of known numbers of moths from emergence cages show that on cool nights the trap catches do not maintain their normal relationship to the daily emergence.

The capture at night in light traps of marked virgin females liberated on the afternoon of the same day indicates that females are attracted and killed before oviposition.

Seventy per cent of the bait pail captures and 43 per cent of the light trap captures were females, but the average catch per trap of both sexes together was so much higher in the light traps that the actual number of females captured per tree was about the same in both bait pails and light traps. In trees which had both bait pails and light traps the light traps captured nearly twice as many females as the bait pails.

The light trap catches indicated a fairly even distribution of the codling moth population thruout the lighted area, with a tendency to smaller catches in smaller trees and slightly larger catches in certain border trees.

THE OCCURRENCE OF *ASCOGASTER CARPOCAPSAE* IN ILLUMINATED AND SPRAYED AREAS OF AN APPLE ORCHARD[1]

By DONALD L. COLLINS, *New York State Agricultural Experiment Station, Geneva, N. Y.*

Ascogaster carpocapsae Viereck appears to be the only larval parasite of the codling moth (*Carpocapsa pomonella* Linn.) occurring in appreciable numbers in western New York. Cox,[2] who made a special study of the biology of this parasite in 1930 and 1931, noted that unsprayed orchards showed a much higher percentage of parasitism than sprayed orchards, these percentages varying from 10 per cent in a sprayed orchard to 41 per cent in an unsprayed orchard. These figures constituted the two extremes from data taken from seven orchards in western New York.

With a control program involving various modifications of standard practice it would not be unexpected that the host-parasite relationship should be profoundly affected. This paper is a study of the results of such a program carried out in a Rome Beauty orchard about thirty-five

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 31, Jan. 29, 1934.

[2]Cox, James A. 1932. *Ascogaster carpocapsae* Viereck, an Important Larval Parasite of the Codling moth and Oriental Fruit Moth. N. Y. Agr. Exp. Sta. Tech. Bul. 188: 1-26.

years old. The manner in which the trees receiving the several treatments were distributed in the orchard is indicated in Figure 17 of the paper by Parrott and Collins appearing elsewhere in this issue. The six categories into which these trees may be divided for the purposes of the present study are as follows:

1. Trees receiving 1 to 4 lead arsenate cover sprays
2. Trees receiving 1 to 4 calcium arsenate cover sprays
3. Trees receiving 2 to 4 calcium arsenate plus bordeaux cover sprays
4. Trees receiving 1 to 4 lead arsenate cover sprays plus light traps
5. Trees receiving 4 cover sprays of each material used plus light traps
6. Lighted trees, including, besides those mentioned in 4 and 5 above, trees receiving no sprays of any kind; trees receiving only lime-sulfur; trees having both light traps and bait pails and receiving no poison sprays.

All trees except the check trees received the standard schedule of lime-sulfur sprays. The trees in the lighted plat which received only lime-sulfur sprays are termed the "standard lighted trees."

The data on numbers of parasitized and healthy caterpillars were taken from banding records, and indicate that the great fluctuations occurring in the host and parasite distribution were more or less directly connected with the control measures involved. Parasitism ranged from 0 where both lights and 4 cover sprays of lead arsenate were used to 30.31 per cent where no control measures were employed.

It is worthy of note that altho in each of the sprayed plats the trees which received only one spray supported a caterpillar infestation that was equal to or greater than the infestation in the check trees, the percentage of parasitism was very much lower, being less than half as high. An explanation of this fact may be that certain spray materials, even tho they are not toxic enough or applied often enough to control codling moth, may bring about a reduction in the percentage of parasitism either directly, by poisoning *Ascogaster* adults, or indirectly, by poisoning parasitized caterpillars which may be less resistant to the poison than healthy caterpillars. This same principle might apply in explaining the fact that while three calcium arsenate cover sprays effected no better control of the host than two sprays, yet with three sprays a drop of 75 per cent in the percentage of parasitism occurred. Further, there is the possibility that lime-sulfur alone may affect the parasite population, for in the lighted check tree, which received no lime-sulfur, the percentage of parasitism was three times greater than in the lighted trees which received lime-sulfur but otherwise were subjected to the same treatment.

Regardless of irregularities among the trees that received two and three sprays, in the case of trees that received four sprays of any of the three materials used both the caterpillar infestation and the percentage of parasitism were lower than with trees receiving one and two sprays. Moreover, in the series in which the best control of the codling moth caterpillar infestation occurred (the plats in which both light traps and lead arsenate were used) the percentage of parasitism was reduced to zero, reductions in both figures taking place concomitantly and coincidentally with the application of the additional sprays. It would appear that the control program which is most effective against the codling moth also reduces not only the parasite population but also the percentage of parasitism, directly by killing the host, and indirectly by killing the adult parasites.

From the data accumulated it was found that the percentage of parasitism was greater in the lighted unsprayed plats than it was in the sprayed plats showing an equivalent control of the host. It was also a matter of record that no *Ascogaster* adults were ever found in the light trap or bait pail catches even tho it was known from observation that they were present in the lighted area. It is possible, of course, that a few specimens may have been captured and burned beyond recognition, but since many insects smaller and more fragile than *Ascogaster* were captured and identified without difficulty, it may be assumed that had *Ascogaster* been captured at least a few of the specimens would have been noted. The influence of light traps upon the *Ascogaster* population, then, could have been only the secondary or indirect effect of reducing the numbers of the host. In the plat which received four calcium arsenate cover sprays the caterpillar population was approximately the same as in the lighted check tree, the standard lighted trees, and the trees having both bait pails and light traps. In every instance the unsprayed lighted trees had a higher percentage of parasitism than the unlighted sprayed trees, and in the lighted tree that received no lime-sulfur, the percentage of parasitism was three times greater than in the sprayed trees where the same degree of caterpillar infestation occurred.

In the lighted area, in the plat having both lights and bait pails, the caterpillar population was lower, but the percentage of parasitism was higher, than in the trees having lights alone. This is not illogical when it is considered that neither method had any known direct effect upon the parasite. With this assumption then, since there were fewer caterpillars in one plat than in the other, theoretically by reason of a control measure which did not kill the caterpillars themselves, and did

not directly affect the *Ascogaster* population, the percentage of parasitism might conceivably be higher in the plat with the lower caterpillar infestation. A corollary of this conjecture might be that reductions in parasitism occurring in the sprayed plats were due more to the primary effect of the sprays on the parasites than to reduction in the numbers of the host.

Several of the facts stated in this paper may in the course of future work prove to have been exceptional, and the speculation which they have engendered may be shaken in the light of additional data. Nevertheless, there are certain conclusions which may be drawn with more or less assurance and for which in the data there is ample evidence:

1. Certain spray programs which are comparatively worthless in reducing codling moth population nevertheless result in a great decrease in parasitism by *Ascogaster*.

2. The most effective sprays and the most efficient spray programs reduce the parasitism by *Ascogaster* in the order of their effectiveness against the codling moth.

3. Light traps and bait pails, being an indirect means of reducing caterpillar population, do not reduce the actual parasite population nor the percentage of parasitism to the extent brought about by a spray program which effects the same degree of host control.

THE EFFECT OF PETROLEUM OIL FLY SPRAYS ON DAIRY CATTLE

By STANLEY B. FREEBORN, *Professor of Entomology*, WILLIAM M. REGAN, *Professor of Animal Husbandry*, and LESTER J. BERRY, *University of California, Davis, California.*

In previous papers the writers (1925, 1928, 1932) have pointed out the following facts bearing on this problem. The loss in milk production occasioned by infestations of house flies and horn flies was negligible; that caused by stable flies, definite; but invariably the loss was augmented when oil fly sprays were used, particularly in hot weather. Burning of the skin often occurred with oils of low viscosity or low unsulfonated residue or with oils of high viscosity unless the unsulfonated residue was also high. The addition of both pyrethrum extracts and of pine oil made the sprays more effective. The environmental temperature of the dairy cow reaches a so-called "pyrexial point" varying between 80 and 85°F, according to breed. When the temperature was kept above this point, the animals were unable to control body temperature, which quickly rose above the normal. Light applications

of petroleum base fly sprays reduced the efficiency of the cow's thermoregulatory apparatus to a point where she lost control of her body temperature at a lower environmental temperature.

Some critics of our work have failed to distinguish between true burning with its attendant visible lesions which can be produced by careless application with practically any commercial petroleum fly spray and the less easily observed but more frequently produced condition wherein the body temperature is raised without evident skin lesions following normal spraying.

Shortly after our publication of 1932, Melvin (1932) and later Wilson, Pearson, and Cannon (1933) published the results of numerous experiments, covering much the same type of data, in which they confirmed all our findings; but in reading the temperatures of the cows under trial overlooked the fact (already pointed out by us) that above given pyrexial points, differing for the breeds, a normal cow, even though unsprayed, cannot control her body temperature. In addition, Melvin pointed out that the body temperatures of dark-skinned cows rose to greater heights than those of pale-skinned cows—a generalized observation, certainly not accurate under varying environmental conditions.

It may be interesting to compare Holstein and Jersey cows at different environmental temperatures. Table 1 shows the comparison.

TABLE 1. PYREXIAL TEMPERATURES FOR DAIRY COWS
SATURATION DEFICIENCY—52–72 GRAINS PER POUND

Room temperature	Body temperature		Rennet coagulation time*				Hydrogen ion*	
	Holstein	Jersey	Holstein		Jersey		Holstein	Jersey
			Normal					
degrees F	*degrees F*	*degrees F*	*min.*	*sec.*	*min.*	*sec.*	*pH*	
75	102.3	101.5	4	35	4	01	6.59	6.57
80	103.3	101.5	5	31	3	45	6.63	6.56
85	103.8	103.1	6	06	4	46	6.64	6.75
		After light spraying (20 cc per animal)						
80		102.8			5	03		6.6

*These data are from the as yet unpublished work of Regan and Richardson.

As this table shows, the Holsteins lost control of their body temperature at 80°F with concurrent changes in the composition of the milk, whereas the Jerseys maintained their normal body temperature until the environmental temperature reached 85°F.

The Jersey cows were maintained for some time at 80 degrees, at which the body temperature and milk characteristics remained normal. An extremely light application (20 cc) of a commercial fly spray was then made daily for ten days. For the first twenty-four hours no change was apparent; but an average for the period, as given at the end of Table 1, shows a persistent and morbid rise in body temperature of approxi-

mately 1°F, with the accompanying milk changes that would have been expected had the environmental temperature been raised approximately 5 degrees.

Circular areas, 35.67 square centimeters in area, were later marked off on the rumps and loins of the Jerseys. Then, by means of inverted Petri dishes, in the bottoms of which were fastened filter papers impregnated with calcium chloride, the amount of moisture transpired by the given area during an hour was determined. At 84°F these areas gave off, on an average, 333.23 milligrams of water an hour. After holding these areas without treatment for several days in order to establish the normal, we treated daily the right rump area on each cow with the amount of commercial fly spray[1] that it would have received in a general light spraying (40 cc per animal) of the entire cow, the surrounding area being protected from the spray. During the first twenty-four hours the difference in moisture transpired was only 32 milligrams less for the treated areas than for the corresponding normal areas; but for the succeeding days of the trial the sprayed areas averaged only 180 milligrams of water an hour, as contrasted with the normal expectancy of 333.23 milligrams, a loss of 153.23 milligrams caused by the oiling.

From the psychrometric room where our original trials were made, these same cows were transferred directly to the respiration chamber, where their total surface and their heat loss on the same rations were computed. Transposing our data measured on the small areas to total surface figures, it appears that the normal loss of moisture at 84 degrees was 413.67 grams an hour, whereas for a lightly sprayed animal it was only 223.22 grams an hour. Translating these figures into terms of cooling power (heat necessary to vaporize these amounts of water at the prevailing temperature and humidity), we find that the normal water output through the skin at the rate of 413.67 grams an hour is responsible for the dissipation of 5698.56 large calories a day at 84°F and 60 per cent relative humidity. On the basis of the sprayed animal, at 223.22 grams an hour, this cooling power is reduced to 3074.88 large calories a day.

[1]A blended spray containing 57 per cent pale oil, 3 per cent pine oil, and 40 per cent kerosene extract of pyrethrum (1.5 pounds of Japanese flowers to the gallon). The blended product has the following specifications:

Gravity (°A. P. I.)	32.9
Viscosity (S. U. @ 100°F)	40.0
Unsulfonated residue	90.0+
Distillation range	
I. B. P.	188°C
F. B. P.	386°C

Data obtained in the respiration chamber showed the total daily dissipation of heat to be 17920 large calories. Hence, 31.8 per cent of a normal cow's cooling power under these environmental conditions is obtained by the evaporation of moisture from the skin. By spraying, this is reduced to 17.16 per cent, a loss of 46.05 per cent in the cooling power produced by moisture evaporation from the skin. The end result is that more heat is produced than can be dissipated; and the consequent rise in body temperature in turn increases the body metabolism, thus producing more heat. Although an animal with a higher body temperature loses heat more rapidly by radiation than one with a normal temperature, if the environmental temperatures remain constant, this factor is decidedly overbalanced by the great loss in heat dissipation occasioned by spraying with oil.

The source of the moisture present on the skin of the cow has caused considerable controversy. Whitehouse, Hancock, and Haldane have shown that water passes freely through the human skin by osmosis or diffusion in increasing amounts as the temperature is increased, until such time as sweating commences, when the saturated surface stops the passage of the so-called osmotic water.

Whitehouse and his collaborators have suggested that the passage of osmotic water through the skin was directly connected with the abundance of capillary blood in the peripheral system. To see whether the oil had a definite effect on the capillaries, we measured the diameter of a given capillary in a rabbit's ear with a binocular microscope and an eyepiece micrometer. Repeated readings at given temperatures gave the following constant results:

Room temperature	50 degrees F	70 degrees F	85 degrees F	90 degrees F
Normal.....	.84 mm	1.05 mm	1.05 mm	1.89 mm
After spraying.....	1.57	1.57	2.10	2.10

A light spraying with a hand atomizer produced, at the end of 24 hours, the results indicated above. Not only did the capillaries fail to contract to their former diameters when the temperature was reduced to 50°F, but they showed a greater dilation at the higher temperatures. Typical inflammation as indicated by the flushing of the tissue was not observed in these trials where the oil was *sprayed*, but we are inclined to attribute to an incipient inflammation the failure of the capillaries to maintain their normal powers of dilation and contraction. Other rabbits whose ears were *swabbed* with the same fly spray showed the same general reaction, which, however, progressed further, resulting in highly flushed tissue, edema, and a fuzzy outline of the arterioles marking a typical mechanical inflammation.

The cow is thought to be very inadequately supplied with sweat glands. Although the actual source of the moisture was not a pertinent point in our investigations, we carefully washed a measured area on the sides of two cows and subjected the animals for two hours to temperatures of 85 and 115 degrees Fahrenheit. Between these exposures the areas were carefully washed with distilled water, which was then analyzed for sodium chloride as an indication of sweat gland activity. The results, 47 milligrams at 85°F and 45 milligrams at 115°F per square meter washed, showed negligible differences. At no time were amounts found that might not have been attributed to extraneous sources. If sweat were an important factor in the moisture production, then proportionally greater increases in chlorides should have been obtained at the higher temperatures. Consequently, it seems safe to attribute the appreciable amount of moisture transpired from the surface of the cow's skin almost entirely, if not wholly, to osmotic water.

Believing that the petroleum oil carrier of the toxics and repellents was the main injurious factor in the spray, we attempted to combine pyrethrum extracts and pine oil in water emulsions. Although these could be applied without injury to the animals, their efficiency against flies was so low that they were modified, the pyrethrum extract and pine oil being combined with a small amount of petroleum oil and then emulsified with water to make a stock solution, capable of further dilution with water at the time of application. The formulas for these emulsions were so arranged that they contained the same amount of pyrethrum and pine oil as had previously been used in sprays employing petroleum oil carriers (1.2 cc of a 19 to 1 pyrethrum extract a cow, and 3 per cent pine oil in 40 cc). We used several different sprays containing the same active ingredients but various emulsifying agents. These were applied immediately after mixing and again when they were six months old. As expected, those containing an alkaline emulsifier, such as potassium abietate, showed a slight deterioration in efficiency at the end of six months' storage, while those utilizing so-called neutral emulsifiers, like diglycol oleate and triethanolamine oleate, remained just as efficient after storage as when freshly mixed. As shown by the net results of the trials, these emulsions were 80 per cent effective over an 8-hour period. In fly-repelling efficiency, they equal or excel the better brands of commercial fly sprays. The best emulsions used have the following formulas:

FORMULA 1

Petroleum oil	84 cc
Unsul. res.	.90
Viscosity	.97
Pyrethrum extract (19–1)	48 cc
Pine oil, steam distilled	48 cc
Sp. Gr.	.9377
B. P.	194–217
Color	1 NPA
Triethanolamine oleate	16 gms
Water	100 cc

Dilute one part of this stock emulsion with four and one-third parts of water.

FORMULA 2

Petroleum oil (as above)	50 cc
Pine oil (as above)	50 cc
Pyrethrum extract (as above)	50 cc
Diglycol oleate	28.9 cc

Dilute slowly with eight parts of water, agitating vigorously.

Applications of these emulsions properly diluted with water caused no rise in body temperature but did produce a loss in the transpired water. Animals treated with the emulsion type spray made with diglycol oleate transpired only enough water to dissipate 24.63 per cent of the total heat, as contrasted with 31.8 per cent for normal unsprayed cows. Apparently increased respiration, sweating at limited, localized areas, and body radiation can compensate for this loss at 84 degrees; but at higher environmental temperatures some rise in body temperature would probably be experienced.

Our first explanation (1925) of the increased temperatures caused by oil sprays was based on the possibility of a mechanical blanketing of the skin, since we were dealing at that time with a pale oil, uncomplicated by toxics or repellents and having a purity from unsaturates comparable to that of medicinal petroleum oil. Scores of trials since that time have always demonstrated two characteristics that refute this idea. In the first place, the effects are never measurable for at least twenty-four hours. Secondly, at the end of the trials, when the animals are scrubbed with warm water and soap to remove the surface oil, the temperature falls as a result of the cooling power of the evaporating water; but it returns by the end of twenty-four hours to its original pre-washing point above normal and in the absence of further spraying gradually recedes over a period of approximately ten days to normal. These observations would seem to preclude the possibility of purely mechanical surface action and point strongly to a chemical combination with the body tissues to produce the resulting conditions. In addition, oils with low unsulfonated residues are certain to produce these unfavorable reactions in a shorter time and with more intense results, which corroborates the chemical nature of the problem.

The rather striking similarity between the effects of petroleum oils on animals and on plant tissue is perhaps worthy of further attention.

LITERATURE CITED

FREEBORN, S. B., REGAN, W. M., and FOLGER, ARTHUR H. 1925. The Relation of Flies and Fly Sprays to Milk Production. Jour. Econ. Ent., **18** : 779–790.

————. 1928. The Relation of Flies and Fly Sprays to Milk Production. Jour. Econ. Ent., **21** : 494–501.

FREEBORN, S. B., and REGAN, W. M. 1932. Fly Sprays for Dairy Cows—A Progress Report. Jour. Econ. Entom., **25** : 167–174.

MELVIN, ROY. 1932. Physiological Studies on the Effect of Flies and Fly Sprays on Cattle. Jour. Econ. Entom., **25** : 1151–1164.

WHITEHOUSE, A. A. R., HANCOCK, W., and HALDANE, J. S. 1932. The Osmotic Passage of Water and Gases Through the Human Skin. Proc. Royal Soc. London, Ser. B, **111** : 412–429.

WILSON, J. L., PEARSON, A. M., and CANNON, C. Y. 1933. The Effects of Some Fly Sprays on the Hides and on the Body Temperatures of Dairy Cows. Jour. Dairy Science, **16** : 427–433.

NOTES ON THE USE OF DERRIS AND PYRETHRUM DUSTS FOR THE CONTROL OF CERTAIN INSECTS ATTACKING CRUCIFEROUS CROPS

By HARRY G. WALKER, *Entomologist*, and LAUREN D. ANDERSON, *Assistant Entomologist, Virginia Truck Experiment Station, Norfolk, Virginia*

The cabbage looper, *Autographa brassicae* Riley, and the larvae of the diamond-back moth, *Plutella maculipennis* Curt., often seriously attack various cruciferous crops near harvest time when it is impossible to use arsenical or fluorine sprays or dusts for their control without running a serious risk of not being able to market the crop because of a poisonous residue on the plants. Because of this situation a great deal of work has been and is being done with Pyrethrum and Derris dusts and sprays as substitutes for the more commonly used fluorine and arsenical insecticides.

The tests herein described were conducted in a broccoli field which was just beginning to head and which was heavily infested with the larvae of the diamond-back moth and cabbage loopers, and moderately infested with Harlequin bugs, *Murgantia histrionica* Hahn. The purpose of these tests was to determine the comparative insecticidal value of various Pyrethrum and Derris dusts, the latter in combination with different carriers, for the control of these three insects.

The tests for the control of the two species of cabbage worms consisted of dusting an equal area or number of plants with each material,

applied with Hudson rotary hand dusters. Check rows were left between each treated area. Records were taken of the amounts of each dust used and of the atmospheric conditions such as temperature, relative humidity, wind velocity, and sunshine. Forty-eight hours after treatment, counts[1] were made on the number of loopers and diamond-back larvae surviving on three lots of five plants in each treated area. These tests were repeated three times with quite similar results. Therefore, the results of all three tests have been combined and are given in Tables 1 and 2. The number of surviving worms given is the total number of worms found on 45 plants and the per cent control is calculated from the reduction in worms as compared to the checks.

The tests for the control of the Harlequin bug consisted of dusting infested plants in the field and immediately collecting and placing the dusted bugs in a circular wire screen cage, which was then set over a dusted plant. The cages were approximately 6 inches in diameter and 12 inches high. About 30 insects were placed in each cage, three cages being used for each application of dust. This treatment was repeated on three different days. Counts were made 24 and 48 hours after treatment, but only the 48 hour counts are given as they seemed to be the most reliable.

Table 1 gives the amounts of dusts used and a comparison of the results obtained with different Derris and Pyrethrum dusts and a standard calcium arsenate dust. The active agents are expressed as the per cent of rotenone in the Derris dusts, of pyrethrins in the Pyrethrum dusts, and of calcium arsenate in the arsenical dust.

A study of Table 1 shows that the Pyrethrum dusts gave better control of the cabbage looper than did the Derris dusts, but that the Derris dusts were superior for the control of the diamond-back larvae. Based on these tests there was practically no difference between the kills obtained with the Pyrethrum-talc dusts containing 0.5 and 0.3 per cent pyrethrins, while the dusts with a 0.1 per cent pyrethrin gave decidedly lower kills. Similarly, there was practically no difference between the kills obtained with the Derris-Inert C or clay dusts containing 1.0 and 0.5 per cent rotenone, while the same dust containing only 0.25 per cent rotenone was less effective. However, where very small quantities of dusts are used, the more concentrated dusts would probably give better results than the weaker dusts. The lower kills

[1]The writers wish to express their appreciation to Mr. John A. Callenbach, Entomologist for the Virginia Smelting Company, for his help in making part of these counts.

TABLE I. THE RELATIVE EFFECTIVENESS OF CALCIUM ARSENATE AS COMPARED WITH VARIOUS CONCENTRATIONS OF PYRETHRUM AND DERRIS DUSTS ON THE CONTROL OF THE LARVAE OF THE DIAMOND-BACK MOTH AND THE CABBAGE LOOPER

Kind of dust	Carrier	Per cent active agent	Amount applied in ounces	Diamond-back larvae		Cabbage looper		Total	
				Number surviving	Per cent control	Number surviving	Per cent control	Number surviving	Per cent control
Pyrethrum	Talc	0.5	58	65	85	14	95	79	89
Pyrethrum	Talc	0.3	42	71	84	10	96	81	89
Derris	Talc	0.5	53	26	94	59	79	85	88
Derris	Inert C	0.5	42	55	87	60	79	115	84
Derris	Inert C	1.0	40	43	90	82	71	125	83
Activated A Pyrethrum	Talc	0.25	50	103	76	24	92	127	82
Ku-ba-tox*		0.4	37	70	84	99	65	169	77
Activated A Pyrethrum		0.5	33	56	64	18	94	174	76
Derris	Inert C	0.25	32	110	75	92	68	202	72
Activated C Pyrethrum		0.135	34	156	64	50	82	206	71
Cubor dust*			31	79	82	157	45	236	67
Sprayrite*		0.43	48	84	81	160	44	244	66
Pyrethrum	Talc	0.1	53	215	51	99	65	314	56
Calcium arsenate	Lime	25.0	38	155	64	207	28	362	50
Check			0	435	0	286	0	721	0

*Commercial brands of Derris dusts.

obtained by the Activated A and C Pyrethrum dusts and the Cubor and Derris-Inert C (Containing 0.25 per cent rotenone) may have been due at least in part to the fact that they did not flow readily through the duster. This also probably accounts for the higher kills obtained with the Activated A Pyrethrum-talc (0.25 per cent pyrethrins) than with the Activated A Pyrethrum (0.5 per cent pyrethrins) dust. Practically all of the Derris and Pyrethrum dusts gave better control at the end of 48 hours than did the calcium arsenate-lime dust.

In general the Pyrethrum dusts gave much quicker kills than the Derris dusts.

Table 2 gives the results of three similar tests conducted for the purpose of determining the most satisfactory carrier for use in combination with Derris dusts. In each case one part by weight of a Derris root dust containing 4 per cent rotenone was mixed with seven parts by weight of each carrier. All of the dusts were mixed just before beginning the first test except the one labelled "lime (old)," which had been prepared for about 60 days. The dusts were all applied by the same operator and with the same duster. The differences in the amounts of dust used were due to the differences in the carriers.

TABLE 2. COMPARISON OF EIGHT CARRIERS FOR DERRIS ROOT DUSTS FOR THE CONTROL OF CABBAGE LOOPERS AND THE LARVAE OF THE DIAMOND-BACK MOTH

Carrier	Amount applied in oz.	Diamond back larvae		Cabbage looper		Total	
		Number surviving	Per cent control	Number surviving	Per cent control	Number surviving	Per cent control
Talc.....	53	26	94	59	88	85	91
Gypsum...	77	39	91	65	87	104	89
Inert C....	39	52	89	87	83	139	86
Lime (new)	47	43	91	124	75	167	83
Flour.....	56	55	88	115	77	170	82
Tobacco...	59	80	82	97	81	177	82
Lime (old).	40	60	87	156	69	216	78
Zinc sulphate-lime	50	81	82	167	67	248	74
Check.....	0	458	0	502	0	960	0

Examination of Table 2 shows that, of the carriers used, talc gave the best control, closely followed by gypsum and Inert C. The large amount of gypsum used was due to its greater weight per volume. The newly made lime dust, flour, and tobacco dusts ranked intermediate, while the old lime and the zinc sulphate-lime gave the poorest control. The only tobacco dust available at the beginning of the tests was rather coarsely ground which probably accounts at least in part for the poor showing. A finely ground tobacco dust was obtained and tested in addition to the coarsely ground tobacco dust in the last two applications. In these two tests the finely ground dust gave almost as good control as the talc and gypsum.

In addition to these tests, gypsum, talc, and Inert C Derris dusts with a 0.5 per cent rotenone content were tested with a traction duster in the field for the control of the larvae of the diamond-back moth and cabbage loopers. In these tests all three materials gave between 77 and 79 per cent control, but a much larger amount of the gypsum-Derris dust was required to cover a given acreage than of the talc or Inert C-Derris dusts, while the Derris-Inert C dust required the least amount for the same acreage.

Table 3 shows the relative effectiveness of six Derris dusts and one Pyrethrum dust for the control of Harlequin bugs. As shown, a Derris-talc dust gave better results than any of the other materials tested, while all of the Derris dusts gave much better results than the Pyrethrum dust, which gave practically no control. However, when the cages were examined 30 minutes after the dust was first applied, it was noted that nearly all of the bugs in the Pyrethrum cages were on their backs, while most of those dusted with Derris were still quite active, but at the end of 48 hours nearly all of the bugs dusted with Pyrethrum apparently had completely recovered, while many of those dusted with Derris had died.

TABLE 3. THE RELATIVE EFFECTIVENESS OF A PYRETHRUM DUST AND VARIOUS DERRIS DUSTS FOR THE CONTROL OF THE HARLEQUIN BUG

Kind of dust	Per cent active agent	Number of tests	Number of insects Used	Dead	Per cent dead
Derris-talc	0.5	9	282	245	86.9
Derris-inert C	1.0	9	288	228	79.2
Sprayrite	0.43	9	269	172	63.9
Derris-inert C	0.5	9	260	156	60.0
Ku-ba-tox	0.4	9	292	172	58.9
Cubor		9	280	159	56.8
Activated A pyrethrum	0.5	9	276	15	5.4
Check		9	263	14	5.3

The results of three tests with a Derris dust in combination with five carriers for the control of the Harlequin bug are given in Table 4. In general, the results agree quite closely with similar tests for the control of the larvae of the diamond-back moth and the cabbage looper, as given in Table 2, with the exception of gypsum which gave slightly better results than talc and of Inert C which gave correspondingly much lower kills than expected. Examination of Table 4 shows that there was considerable variation in the kills obtained with a given dust on different days. Ordinarily, fairly good results have been obtained with some of the Derris dusts in field control of Harlequin bugs, but occasionally very poor results are obtained with the same dust under

approximately the same conditions, the reasons for which have not yet been determined.

TABLE 4. A COMPARISON OF FIVE CARRIERS FOR DERRIS ROOT DUSTS SHOWING FLUCTUATIONS THAT MAY OCCUR IN KILLS MADE ON DIFFERENT DAYS FOR THE CONTROL OF THE HARLEQUIN BUG

	Test No. 1		Test No. 2		Test No. 3		Total	
Carrier	No. of insects	Per cent dead	No. of insects	Per cent dead	No. of insects	Per cent dead	No. of insects	Per cent dead
Gypsum..	89	98.9	62	37.1	60	50.0	211	66.8
Talc.....	96	97.9	59	40.7	57	26.3	212	62.7
Flour.....	94	69.1	59	6.8	60	10.0	213	35.2
Inert C...	78	74.4	61	3.3	59	13.6	198	34.3
Lime.....	94	74.5	60	0.0	56	1.8	210	38.3
Check....	93	3.2	78	1.3	60	1.7	231	2.2

INSECTICIDAL PROPERTIES OF COMPLETELY EXTRACTED DERRIS ROOT RESIDUE

By JOSEPH M. GINSBURG, Ph.D., *Biochemist in Entomology*, and PHILIP GRANETT, *Graduate Assistant, New Jersey Agricultural Experiment Station*

ABSTRACT

Toxicity tests with derris root powder and its exhausted residues, after extraction with acetone and with acetone followed by water, were carried out against chewing and sucking insects. Silk moth larvae, cabbage worms and apple aphis were used. The materials were applied in form of coarsely and finely ground dusts. The results suggest the following conclusions.

Derris root dust is very toxic to sucking and chewing insects. Against aphis, the toxicity was greater when the dust was applied on wet foliage than on dry foliage. Residues from derris root completely extracted with acetone possess practically no toxicity to aphis, but are both toxic and repellent to caterpillars. Residue from derris root extracted first with acetone and then with water does not seem to possess direct toxicity to caterpillars but acts as a deterrent, preventing them from feeding on the dusted foliage. (Paper withdrawn for publication elsewhere.)

HALOWAX AS A CONTACT INSECTICIDE

By E. P. BREAKEY, *Crop Protection Institute Investigator, The Ohio State University, Columbus, Ohio*

The purpose of this paper is to introduce to the entomological profession a synthetic product, the insecticidal properties of which have been demonstrated. The search for less costly and more effective insecticides led to the consideration of a synthetic oil, a chlorinated naphthalene product produced by the Halowax Corporation. Our studies have produced some outstanding results which warrant recording at this time.

The work is being done as a Crop Protection Institute project in cooperation with the New Hampshire Experiment Station and the Ohio State University, the directing committee being Professor D. M. De Long, chairman, and Professor W. C. O'Kane. Preliminary tests of the material in several combinations were made at the New Hampshire Experiment Station. These have been continued by the writer in the Entomological Laboratories of the Ohio State University and in certain areas of Florida.

PROMISING COMBINATIONS.—An emulsion of Halowax and C P O soap (potash cocoanut oil soap) when diluted to contain 0.5% Halowax[1] and 0.25% soap on the dry weight basis, gave 52% mortality of the apple aphid, *Aphis pomi* De G. A similar emulsion, when diluted to contain 2% Halowax and the same amount of soap, gave 100% mortality of *Aphis pomi* De G. Another combination, when diluted to contain 1% Halowax and 0.25% C P O soap, killed 70% of the green chrysanthemum aphid, *Rhopalosiphum rufomaculatum* Wils. C P O soap alone at 0.25% on the dry weight basis gave 7% mortality of *Aphis pomi* De G.

Sulphur is soluble in Halowax in very small amounts. An emulsion of Halowax in which sulphur had been dissolved proved to be especially effective against red spiders. When diluted to contain 1% Halowax, some sulphur, and 0.25% C P O soap, this emulsion gave 100% kill of the red spider, *Tetranychus telarius* L., 90% kill of the bean aphid, *Aphis rumicis* L., and 100% mortality of the chrysanthemum aphid, *Macrosiphum sanborni* Gill. The same combination from which the sulphur had been omitted gave 71% kill of *Aphis rumicis* L.

A similar emulsion of Halowax with sulphur, when diluted to contain 1% Halowax, some sulphur, and 0.5% liquid C P O soap, gave 100% kill of *Tetranychus telarius* L., 90% kill of *Rhopalosiphum rufomaculatum* Wils., 100% kill of *Macrosiphum sanborni* Gill., 100% kill of *Aphis rumicis* L., 95% kill of the woolly hawthorne aphid, *Eriosoma crataegi* (Oestl.), 100% kill of young mealy bugs, *Pseudococcus citri* (Risso), 100% kill of onion thrips, *Thrips tabaci* Lind., and 75% mortality of inch-long larvae of the walnut datana, *Datana integerrima* G. & R.

It has been shown by de Ong (1) and others that highly refined spray oils are not particularly toxic to insects. In order to secure a petroleum oil suitable for insecticide purposes, unsaturated hydrocarbons are largely removed, since Gray and de Ong (2) and others have shown that it is these which are largely responsible for plant injury. In order

[1]All proportions are by weight.

to secure a percentage-kill high enough to give a satisfactory degree of control, it is necessary to use oils which are so heavy, or to use such a high percentage of oil in the spray that injury may result to the plants. The nature of this injury has been demonstrated by Knight (3) and his associates. Smith (4) reports an unsuccessful attempt to increase the effectiveness of spray oils by the addition of toxicants.

The addition of Halowax to a typical white oil greatly increases the toxicity of the oil. A combination of the white oil, *Nujol*, and Halowax emulsified with C P O soap and diluted to contain 2% white oil, 1% Halowax, and 0.25% soap on the dry weight basis, gave 87% mortality of mealy bugs, 100% mortality of bean aphids, and 100% mortality of red spiders. As a check, a spray containing 2% of white oil alone, emulsified with C P O soap, gave 8% kill of mealy bugs and 33% kill of red spiders.

Another combination of white oil and Halowax, when diluted to contain 1% of each and 0.5% liquid C P O soap, gave 100% mortality of *Tetranychus telarius* L., 100% kill of *Macrosiphum sanborni* Gill., 90% kill of the rose aphid, *Macrosiphum rosae* L., 98% kill of *Eriosoma crataegi* (Oestl.), 100% kill of immature mealy bugs, 100% kill of *Thrips tabaci* Lind., and 70% kill of inch-long larvae of *Datana integerrima* G. & R.

Field Tests.—The combinations, Halowax with sulphur and Halowax and white oil, were given more extensive testing under field conditions in Florida, in the winter gardens near Miami and in the Sanford area. Up to this time, the various preparations under test had been combined at the New Hampshire Experiment Station by Mr. W. A. Westgate. Starting with the work in Florida, the emulsions have been combined at the Halowax Laboratories in Bloomfield, New Jersey.

It soon became evident that the toxicity of the emulsions as combined at Bloomfield greatly exceeded that of the same as combined by Mr. Westgate. The emulsion of Halowax and white oil proved to be a better scalecide than did the emulsion of Halowax with sulphur. Trees and shrubs were tolerant to much higher concentrations of Halowax than were vegetable crops, in some instances three and four per cent being harmless. In most instances, new growth was coming on when the spray was applied. Insoluble soaps formed when the emulsions were diluted with the waters available, resulting in a troublesome sludge. This called for the use of an emulsifying agent in place of the C P O soap which would not be salted out by the various alkalies present in the waters available for diluting the emulsions.

On returning to Columbus, it was found that the toxicity of the emulsions as combined at Bloomfield is approximately double that of the same when prepared in the laboratory. The amount of this rise in toxicity was determined by repeating many of the tests previously made with the emulsions prepared in the laboratory, running the concentrations down until comparable results were obtained.

COMPARATIVE TESTS.—The most promising combination developed so far is one containing equal parts of Halowax and a white oil (80–85 viscosity and 90+ sulfonation value) with sufficient water and emulsifier, or emulsifier and stabilizer, added to produce the desired emulsion. When this emulsion is diluted to contain 0.5% of each, it is an effective insecticide against aphids, thrips, scale insects, red spiders, immature mealy bugs, and white flies, except perhaps the pupae. At this dilution, it is practically 100% effective against such insects, surpassing many of the better known insecticides in parallel tests. There is still some doubt as to its ability to kill the pupae of Aleurodids and fully developed mealy bugs. When diluted to contain 0.33% of each, it is effective against red spiders, many aphids, and some thrips. In fact, our experience has been that Halowax might be considered a specific insecticide for red spiders. The spiders themselves are not only destroyed, but their eggs fail to hatch after being wet with the spray.

The combination of Halowax with sulphur also possesses marked possibilities as a contact insecticide, though recently put aside in order to develop the other more fully. Diluted to contain 0.5% Halowax, it compares very favorably with other leading contact insecticides. Like the above, it makes an especially favorable showing against red spiders. It has one distinct advantage over the Halowax and white oil combination in that it does not injure the waxy bloom on such plants as carnations.

Comparative tests were run to check the insecticidal efficiency of the Halowax and white oil combination against several leading contact insecticides. In selecting the insecticides, we attempted to obtain one deriving its insecticidal properties from highly refined petroleum oil, one from nicotine, and one from pyrethrin. The accompanying chart has been prepared from our data sheets and gives a fair indication of the comparative insecticidal values of the four preparations.

GREENHOUSE TESTS.—We are now engaged in determining the behavior of the Halowax and white oil combination when used under greenhouse conditions. The combination as first prepared, when diluted to contain 0.5% of each, produced considerable burning on such tender crops as cucumbers and tomatoes. Tomatoes were especially

susceptible to injury. However, casein and blood albumen have provided a marked degree of safety. When used at the rate of one part by weight in one thousand parts of the dilute spray, they usually pro-

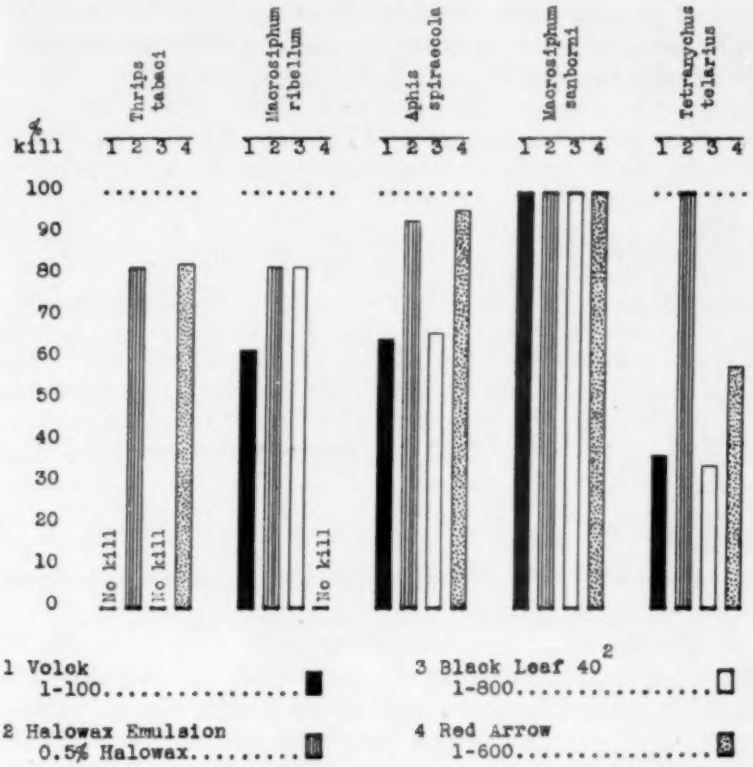


FIG. 23.—Comparative Tests of the Halowax and White Oil Emulsion with Volck, Red Arrow, and Black Leaf 40 (Based on three or more tests.)

vide the desired freedom from injury. It requires somewhat more of either to give the same degree of safety to the Halowax with sulphur preparation. This increase in safety seems to be correlated with the improved "run off" obtained. Our experience in these studies has been that blood albumen is superior in behavior to casein.

Blood albumen, when used as suggested, has much better keeping qualities than casein. A sample of the Halowax and white oil emulsion,

[2]Soap was not used since it was thought best not to bring the element of a spreader into these tests.

diluted as for use and containing blood albumen in the proportions indicated, has stood on our laboratory shelves at room temperatures for eight weeks, apparently without deterioration, while a similar sample containing casein showed deterioration at the end of one week. Also, the blood albumen, when finely ground, dissolves readily in the water used to dilute the emulsion, while the casein must be digested before it is added to the spray.

LITERATURE CITED

1. 1927, DE ONG, E. R., KNIGHT, HUGH, and CHAMBERLIN, J. C. A Preliminary Study of Petroleum Oil as an Insecticide for Citrus Trees. Hilgardia 2: 251–384.
2. 1926, GRAY, G. P., and DE ONG, E. R. California Petroleum Insecticides. Ind. and Eng. Chem. 18: 175–180.
3. 1929, KNIGHT, H., CHAMBERLIN, J. C., and SAMUELS, C. D. On Some Limiting Factors in the Use of Saturated Petroleum Oils as Insecticides. Plant Physiology. 4: 299–321.
4. 1932, SMITH, RALPH H. Experiments with Toxic Substances in Highly Refined Spray Oils. Jour. Econ. Ent. 25: 988–994.

THE ROLE OF SOME SOUTHERN PINE PRODUCTS IN THE CONTROL OF *APHIS RUMICIS* LINN.

By C. O. EDDY, *Kentucky Experiment Station, Lexington, Ky.*

There are a number of types of pine products and a number of ways each may be used as contact sprays or with contact sprays. This study is confined to pine tar and pine tar oil in water soluble form as they assist soap or soap-nicotine solutions in aphid control The study was started with the expectation of finding so-called chemical activators or accelerators for nicotine somewhere in the group of pine products.

HARD SOAPS.—Pine tar or pine tar oils may be incorporated with hard soap, either as completely saponified or partly saponified tar or tar oils. When completely saponified resulting solutions are usually clear reddish brown to transmitted light and a milky white opalescence to reflected light. When the tar oil is only partly saponified the solutions with water are muddy in appearance, thus indicating the presence of emulsified particles. Both types are found on the open market. With hard soaps it is possible to use up to seven or 10% of the tar or tar oil in the actual soap and still retain good soap characters in the product. Above these percentages the soaps are difficult to make and use. These hard

soap products are difficult to make in the ordinary laboratory. With hard soaps it is also impossible to study large variations in the tar or tar oil content. They are also less convenient for use in general spray purposes. For these reasons studies were made with liquid soaps.

LIQUID SOAPS.—By using liquid soap large variations of tar or tar oil content may be observed. This project, however, is not concerned with those proportions where the tar or tar oil is the major portion and may range as high as 80% or 90% with 10–20% alkali and water or alkali, water and soap. It is concerned with proportions of less than 50% where the tar or tar oil serves to increase the toxicity of the soap or the soap-nicotine solutions.

Just as with the solid sodium soaps, the tar and tar oils may be emulsified by the soap or they may be saponified with alkali and water and used with soap in water soluble form, or they may be partly emulsified and partly saponified. This report is concerned only with those completely saponified. The dilutions of these completely saponified products are usually reddish brown by transmitted light and a milky white opalescence to reflected light.

Liquid soaps, however, even when made with caustic potash contain 40% or less of dry weight soap. This is somewhat less than half the dry weight of the good hard soaps. Liquid potash cocoanut oil 40% or potassium oleate 40% were convenient to use. The former was selected.

Saponified tar oils and tar can be incorporated in this soap in several ways. When the sum of the two is 40% or not much above, the process is relatively easy. When more than that the process is more difficult. The cocoanut oil and tar or tar oils may be mixed and saponified together in the presence of moderate heat. This process is facilitated by the presence of the rather large amount of water. This process is quicker and more satisfactory than saponifying them separately and then putting them together. Or, potash cocoanut oil (60% paste or 40% liquid) may be added to saponified or partially saponified tar or tar oil and heat applied. The heat and soap will complete the saponification of any unsaponified tar or tar oil if alkali for it is present.

When tar or tar oil is saponified alone, it must be done in the presence of some water. This process is aided by gentle heat. Solvents like alcohol, acetone, ether, etc., hasten and make saponification easier, either when tar or tar oil is alone with required alkali, or when done in the presence of soap or saponified cocoanut oil. These combinations require an excess of alkali to keep them in solution and out of emulsion. Likewise, if too little alkali is used, they may be alkaline in reaction in concentrated form but become acid on dilution. It is important to

watch this factor as it makes a difference in the toxic value of both the soap and the nicotine in the experiments.

When the combined total of potash cocoanut oil and tar or tar oil is much above 40% of the solution, the combination must be really boiled under pressure or under a reflux condenser if the cocoanut oil is half or more of the mixture. In these cases it was found best to use the soap at 36% dry weight, or below. Above that the mixtures in these experiments became pastes or it was impossible to fuse them.

Tests with aphids showed:

1. Some tar and tar oils of pine improve wetting efficiency of potash cocoanut oil soap. Others decrease wetting efficiency. Some of the water soluble tars reduced the surface tension as much as ten dynes or more. In general the experiments showed that tar oils of pine were more efficient than the pine tars.

2. Some tars and tar oils added to actual toxicity of the cocoanut oil soap or to the soap-nicotine solutions. In general the tar oils containing the higher fractions were most effective. The most effective sample started boiling at nearly 200° C. The least effective (those reducing spread and toxicity) were the crude pine oils containing many light fractions and fewer of the oily-like and higher fractions. These compounds seem to add their own toxic properties to these solutions above that of the soap or of soap and nicotine.

3. The use of tar oils makes it possible to ship liquid cocoanut soap-combination spreaders containing more than 40% of active ingredients.

4. Tests failed to show the presence of so-called activators of accelerators in tars or tar oils of southern pine. Tests showed many have toxic properties but add to toxicity of cocoanut oil soap or soap nicotine combinations due to chemical activity and to improvement of physical structure of the spray solution.

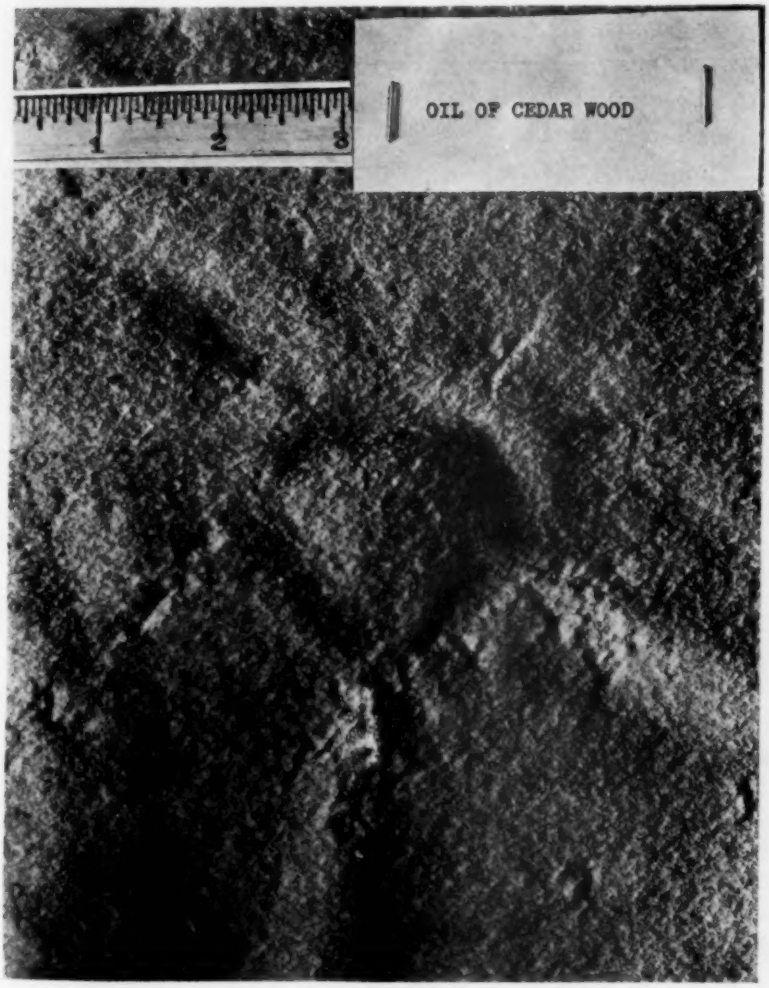
5. Tests showed excellent value of cocoanut oil soap as toxic agent for aphids and as a spreader for nicotine. They further showed a way this toxicity may be supplemented by use of tars and tar oils of pine (the latter being more important in our tests).

6. In hard waters of Kentucky, with small sprayers on smooth foliage, such as nasturtium, it is necessary to use 4 parts cocoanut-tar oil spreader per 1000 parts of water. At this concentration nicotine 50% at a dilution of 1-3000 gave commercial control in the greenhouse on *Aphis rumicis* Linne. and on a green species (unnamed).

PARADICHLOROBENZENE, NAPHTHALENE AND THE CEDAR OILS INEFFICIENT AS REPELLENTS AGAINST CLOTHES MOTH ADULT

By SAMUEL C. BILLINGS, JR., *Entomologist, Food and Drug Administration U. S. D. A.*

In connection with the enforcement of the Insecticide Act of 1910 it was found necessary to test cedar wood oil, cedar leaf oil, naphthalene and paradichlorobenzene as repellents against adults of the webbing



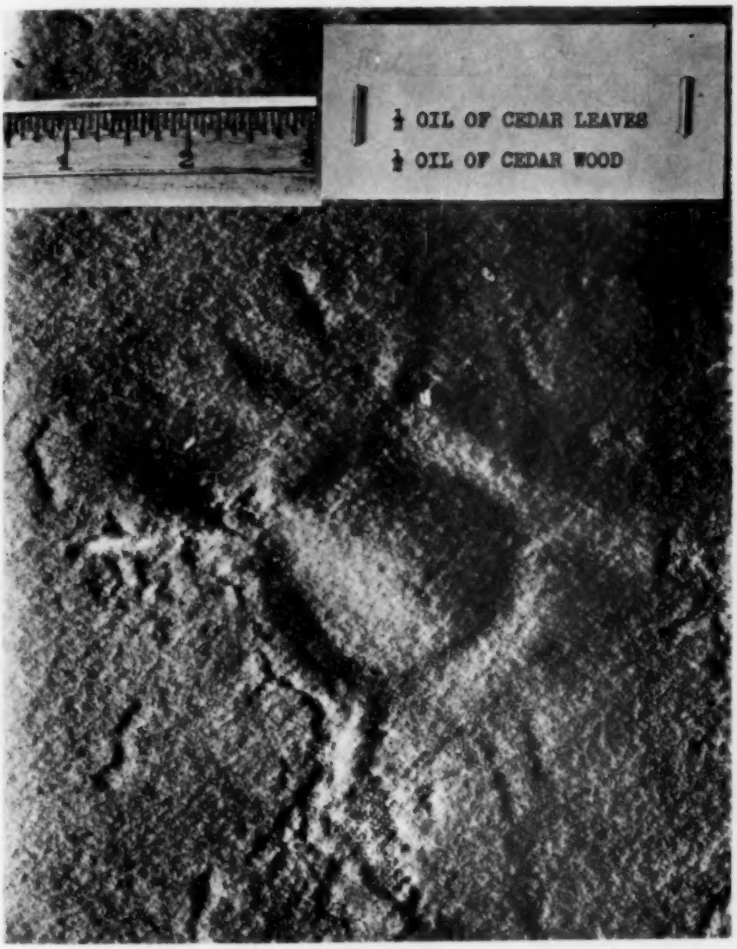
See following pages for treatments, reduction indicated by the rule

clothes moth, *Tineola biselliella Hum.*, to determine the accuracy of the claims, made on the labels of proprietary products containing one or more of these ingredients, that they acted as moth repellents. It was shown by L. J. Bottimer in 1929[1] that paradichlorobenzene and naphthalene would not repel moth larvae but no work was done with these substances to determine their action against the adult moth.

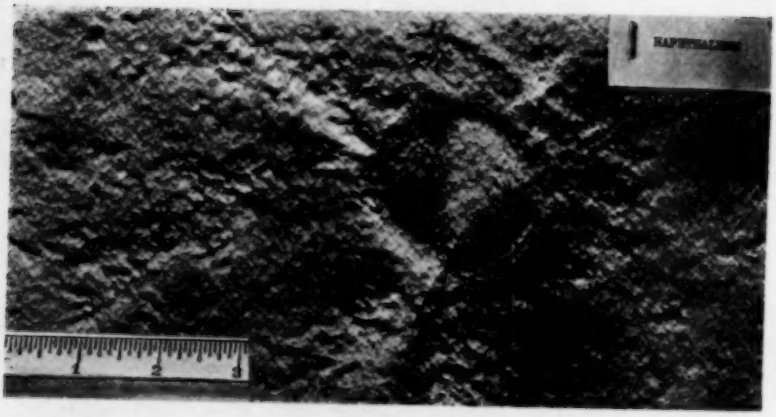
In conducting tests to establish whether or not these materials had any effective repellent value, four bottles of four ounce capacity were nearly filled with the ingredients listed and a fifth was filled with half and half cedar wood and cedar leaf oils. A piece of flannel was secured over the mouth of each of the five bottles by means of a rubber band. It was observed that the odor of the various materials, emanating from the mouth of the various bottles, penetrated the flannel and could be distinctly observed for several inches around. These five bottles were

[1]Jour. of Econ. Ento. Vol. 22, No. 3, pp. 570–573, 1929. Notes on Paradichlorobenzene and Naphthalene as Repellents against Clothes Moth Larvae.

placed upright on raw wool in a well-infested moth breeding cage where adults were abundant. This cage was fitted with constant temperature apparatus adjusted to 78°F. The experiment was started on April 11,



1933; fifteen days later, eggs and young larvae were abundant on the nap or under side of each of the five pieces of flannel. Of course the circular portion of the nap side of the various pieces of flannel was uninjured as moths could not reach this area since it was tightly secured over the mouth of the various bottles. With this exception it was noted that the eggs and larvae were distributed approximately evenly over



PARADICHLOROBENZENE

the under surfaces of the various pieces of flannel. The bottles with flannel in place were then placed on a shelf in a constant temperature room (80°F) and a small amount of dry yeast[2] was sprinkled over the flannel. On June 8, 1933 each of the five pieces of flannel was badly gutted by moth injury. Holes were eaten in the flannel and the nap was entirely eaten away over large portions of the surface. These pieces of flannel were removed from their respective bottles, thoroughly fumigated to kill the larvae, and then photographed. (See illustrations.) In another experiment similar bottles of paradichlorobenzene, naphthalene and cedar wood oil, covered with flannel, were placed in three corners of a three foot square screen cage. In the other corner another flannel covered bottle, containing water, was placed. From time to time large numbers of adult moths were liberated in the cage. In due course eggs were deposited on all four pieces of flannel, they hatched and the larvae fed in the usual manner. There was no noticeable difference in the extent of the damage on the different pieces of flannel.

In experiments with adult tapestry moths, *Trichophaga tapetzella*, eggs were laid on a flannel bag that contained paradichlorobenzene, although flannel and a large supply of feathers were equally available for egg deposition. Eggs were also laid on the untreated flannel.

Tests with numerous proprietary preparations that contained one or more of these ingredients have given identical results. The value of these materials as fumigants was not considered in this work.

SOME EFFECTS OF ETHYLENE OXIDE ON THE VARIOUS STAGES OF THE BEAN WEEVIL[1] AND THE CONFUSED FLOUR BEETLE[2]

By WILLIAM R. HORSFALL, *Monticello, Kans.*

During the past three years a study was made of the effects of the vapor of ethylene oxide on some of the stages of both the bean weevil and the confused flour beetle in connection with other work at Cornell University. The research was made under the direction of Professor G. W. Herrick and was incorporated as a part of my thesis which was submitted in partial fulfillment of the requirements for the degree of doctor of philosophy.

[2]Colman, W. 1932 our. of Econ. Ento. Vol. 25, No. 6, p. 1242. Effect of yeast on Clothes Moth Larvae.

[1]*Mylabris obtectus* Say. Family—Mylabridae, Order—Coleoptera.

[2]*Tribolium confusum* Duv. Family—Tenebrionidae, Order—Coleoptera.

DEFINITION OF TERMS.—*Prepupa* as used here in connection with the confused flour beetle will be understood to mean those larvae which were so inactive that they were unable to burrow into white flour when placed on it. *Emergence* when used in connection with the bean weevil will be understood to mean the exit from the bean.

METHOD OF TREATMENT.—As far as apparatus and fumigation technique is concerned, it will suffice to say that it was the same as that of Herrick and Horsfall (1931) with a few exceptions. All stages were treated in small bags made of bolting silk, and after the treatment, they were transferred to small seamless tin boxes for rearing. In addition, the rearing was carried on in an incubator where the temperature was maintained within a degree of eighty degrees Fahrenheit, and where the relative humidity was maintained roughly at fifty per cent.

RESULTS

IMMATURE STAGES.—The preliminary observations were made of the effects produced on different lots of bean weevils which were known to be mixtures of pupae, prepupae, and old larvae. The specimens were treated in the beans without otherwise being disturbed. After exposing them to the gas, they were placed in small tin boxes and reared to maturity. The first adults to emerge were apparently normal. Three or four days after the beginning of emergence many of the males and females that emerged had either a shiny black or reddish brown cuticula, or the wings or the legs were deformed. Then toward the end of the emergence period normal apendages and color were to be seen on the adults. The indications are that the prepupae were the ones affected.

Because the bean weevil spends all of its immature stages subsequent to the egg within the seed coat of the bean, it was not very satisfactory as an insect with which to demonstrate which of the stages was most affected by the gas. Hence another was sought to fill the requirements. A culture of the confused flour beetle which had been used for some other studies proved to be very satisfactory. Only pupae and prepupae were used because their ages could be accurately determined.

TABLE 1. EFFECT OF 44G. OF ETHYLENE OXIDE PER 100 CUBIC FEET ON PREPUPAE

Hours treated	Number treated	Number normal	Number with elytra spread	Number with elytra short	Number with elytra short and legs unsclero-tized	Number with hooked antennae	Number dead
3	20	10	3		1		6
4	11	2	2	5	1		1
6	20			1	2	1	16
Total	51	12	5	6	4	1	23
Check	33	33					

TABLE 2. EFFECT OF 44G. OF ETHYLENE OXIDE ON PUPAE

Hours treated	Number treated	Number normal	Number with elytra spread	Number unable to shed pupa skin	Number dead
3	17	16		1	
6	36	25	5		6
Total treated	53	41	5	1	6
Check	36	36			

Only twelve adults were apparently normal that emerged from the fifty-one treated prepupae, whereas forty-one superficially normal adults emerged from the lot of fifty-three pupae similarly treated. It is also interesting to note that not one of the check was in any way abnormal. As far as size and shape of appendages were concerned, no differences were found between those of the adults emerging from the lots treated as pupae and those of the checks. Some of the adults were unable to hold the elytra so that they met in a straight line down the back, but otherwise they were normal. On the other hand, a treatment

TABLE 3. EFFECT OF 44G. OF ETHYLENE OXIDE ON OVIPOSITION

Exposure in minutes	Check	15	30	45	60	75	90	105
Number of females	32	31	37	31	32	31	31	31
Days after treatment								
1	33		1					
2	288	162	69	6				
3	420	447	391	64—	11			
4	433	335	325	174	43	1		
5	176	243	217	154	45	8		
6	70	92	152	169	16	15		
7	25	46	117	115	51	12		
8	22	46	25	41	37	4		
9	18	60	36	37	17	4	13	
10	1		59	7	12	20		
11	2				4	58	24	
12		7	4			22	3	
13								
14					3	42	4	
15						19		
16					1	5		
20					1			
Total eggs	1488	1438	1396	767	241	210	44	
Average eggs per female	46.5	46.3	37.7	24.7	7.5	6.7	1.4	
Mean oviposition	3.7	4.2	4.7	5.5	6.5	10.8	10.7	
Per cent hatch	95	92	88	71	83	46	3	

of the prepupae caused six adults to have short elytra, four more to have unsclerotized legs in addition to short elytra, and one with both antennae distorted toward the apex. Twenty-three of the treated prepupae failed to mature and only six of the pupae were killed. From these data it seems clear that the prepupae were more susceptible to the action of ethylene oxide than were the pupae.

ADULTS.—Because the bean weevils have such a short adult life and

the period of oviposition is concentrated into a relatively short period, they were used to show the effects of the vapor on that stage. All of the treated adults emerged from the beans within a period of twenty-four hours previous to the treatment. In Table 3 which follows, the exposures were short in order to compare the amount of oviposition and the extent of the decrease with the length of the exposure.

Table 3 shows that the oviposition was both inhibited and retarded as the exposure increased. In addition the number of eggs per female decreased from 46.5 in the check to 1.4 and none in the lots exposed for 90 and 105 minutes respectively. The number of days before the mean oviposition varied from 3.7 to 10.8 up to the exposure of 90 minutes duration. The eggs that were produced by the adults subjected to the longer exposures did not hatch as well as those produced by the checks.

In view of the fact that both males and females were treated together in the above experiments, it became necessary to run an experiment to see which, if either, sex was the more affected. In the check neither the males nor females were treated; in another lot only the males were subjected to treatment; and in the third lot only the females were treated. In order to be sure only unmated insects were used, only those that had cut their exit holes but had not escaped from the pupal chambers were taken.

TABLE 4. EFFECT OF 44G. OF ETHYLENE OXIDE ON ADULT BEAN WEEVILS WHEN EXPOSED 82.5 MINUTES

Treatment	Check	Treated males	Treated females
Total eggs	427	445	1
Per cent hatch	87	92	0
Number of females	10	10	10

From Table 4 it will be seen that the treated males were quite as capable of fertilizing the females as were the males of the check. Both the males in the check and those that were exposed to ethylene oxide lived for the same period showing that even for this exposure the gas did not act to shorten the life of the males. On the other hand, several of the treated females were killed outright while a few lived about the normal span. Those females that lived failed to produce any viable eggs. These data based on the treatment of a few unmated weevils while meagre in themselves support those given in Table 3 and enable one to conclude that all retardations and inhibitions of oviposition resulted from the effects produced on the females rather than on the males.

CONCLUSIONS.—All of the data presented above tend to point to the one essential conclusion that ethylene oxide affects that stage or portion

of these two insects that is undergoing the greatest cellular activity. During the prepupal life of the confused flour beetle, the histoblasts which determined the adult appendages were injured so that an abnormal development of those appendages resulted. The data from the experiment dealing with the effects on oviposition show that the amount of oviposition was decreased and the mean oviposition was retarded as the length of the exposure was increased. In the experiment designed to ascertain which sex was injured the more by the vapor, the data show that the treated females reacted more than the males.

Undoubtedly the maturation of the eggs requires a large amount of oxygen hence it is to be expected that the young females would use more than the males. Similarly, the developing histoblasts in the prepupal stage must require the intake of considerable oxygen. It is thought that the factors favoring an increased intake of oxygen also favor the intake of ethylene oxide.

SUMMARY OF RESULTS.—Ethylene oxide was found to have the following effects on the various stages of the bean weevil and the confused flour beetle:

1. A disturbance of the normal development of the histoblasts that determine the adult appendages was produced when prepupae were treated.

2. Pupae were found to be injured less than the prepupae.

3. A treatment of adults caused a decrease in oviposition, a delay of the oviposition, and more inactivity on the part of the females as the length of exposure increased.

4. Unfertilized females were killed or prevented from ovipositing by an exposure that had no effect on the males.

LITERATURE CITED

HERRICK, G. W., and HORSFALL, W. R. The reproductivity of the bean weevil (*Mylabris obtectus* Say) as affected by the vapor of ethylene oxide. Journal of Economic Entomology. 24: 1084–1086 October, 1931.

ARSENIC DEPOSIT AND CODLING MOTH CONTROL[1]

By R. L. WEBSTER, *Washington Experiment Station, Pullman, Washington*

Ten years ago it was common practice in the Pacific Northwest to use lead arsenate at two pounds to 100 gallons of water. Even as late as 1930 this concentration was recommended, although it was generally admitted that three pounds were needed in case of a heavy infestation. During this period washing equipment steadily was improved, a better knowledge of washing solutions was accumulated, and little difficulty was involved in meeting the arsenic tolerance of .01 grain per pound of fruit when lead arsenate was applied at the higher concentration.

Investigations by Anthony Spuler in 1929 indicated clearly that the increase in efficiency in worm control mounted rapidly until a concentration of between three and four pounds of lead arsenate per 100 gallons was reached. Additional quantities resulted in only slight increases in worm control.

A year ago, at the Washington State Horticultural Association, it was pointed out that when the concentration of lead arsenate was increased from three to six pounds, there was a gain in sound fruits of only about two per cent. Washington apple growers are now approaching rather definite limits in the matter of increasing the amount of lead arsenate which may profitably be used.

It has come to be generally recognized, at least so far as lead arsenate is concerned, that protection from codling moth attack depends on two main factors: First, the amount of deposit; second, the nature of the spray coverage.

METHODS AND MATERIALS USED.—Studies on arsenic deposits have been conducted for several years by the Washington Experiment Station and until 1933 had reference only to lead arsenate. This year, because of the need for further information on the feasibility of replacing lead arsenate with other non-lead arsenicals, deposit studies were extended to include calcium arsenate, manganese arsenate, zinc arsenite and zinc arsenate. Following methods utilized by Spuler in 1930, analyses have been made of the quantity of arsenic trioxide present following the application of different cover sprays—usually soon after the spray treatment, on occasion immediately before the spray application. During the 1933 season approximately 400 separate analyses for arsenic were made. Most of these analyses have been done by Cecil E. Miller,

[1]Published as Scientific Paper No. 280, College of Agriculture and Experiment Station, State College of Washington.

graduate assistant in entomology at the Washington Experiment Station.

Loss in Deposit During Season.—Careful studies made by Spuler and his associates in the Wenatchee district have shown that when straight lead arsenate is used there is a loss in deposit per unit area of apple surface which amounts to as much as 3.6 per cent of arsenic daily between cover sprays early in the season. Most of this loss is due to increase in size of the apples. Later in the season, during the cover sprays for first brood, the daily loss in deposit was from 1.3 to 1.6 per cent, while during the second brood sprays, when the actual surface of the apples increased slowly, the daily loss in deposit was less than one per cent. No doubt the loss in spray deposit in eastern states is much greater because of greater rainfall. The annual rainfall in the principal apple growing regions of eastern Washington does not exceed 10 inches.

Deposit Necessary for Control.—In our recommendations in the Pacific Northwest we have said that an average deposit of not less than 80 micrograms of arsenic per square inch of apple surface must be maintained in order to prevent most of the worms from gaining access to the growing fruit. If maintained until harvest, such a deposit would amount to .125 grain of arsenic per pound, a high arsenic load, and one that may often resist removal by ordinary washing methods.

Failure in Severe Infestations.—Even high deposits of straight lead arsenate may not be sufficient to check worm damage where there has been a large carry-over of larvae from the previous year, especially when followed by a season particularly favorable to the codling moth. This was true in 1932, when late entering worms, made inroads into maturing fruit, even where heavy applications were made throughout the season. In a block of six Jonathan trees in the experimental orchard at Wenatchee, where six cover sprays of lead arsenate 3:100 were applied, there was at harvest 23.2 worms per 100 apples. In this case there was a deposit of 125 micrograms per square inch when the analyses taken immediately after spraying were averaged. The true average deposit was, of course, lower but could scarcely have been less than 80 micrograms. Further evidence of a heavy deposit is evidenced by the arsenic load of .081 grain per pound at harvest.

Again in 1933 in Jonathans in the experimental orchard straight lead arsenate 3:100 failed to stop the worms, and the infestation varied from 23.4 to 30.5 worms per 100 apples. An average of five analyses, four of which were on fruit picked immediately after spraying, indicated a deposit of 157 micrograms per square inch.

To make sure of high deposits, plenty of spray material is necessary.

Twenty-five to thirty gallons of spray liquid is needed for an average eighteen year old Jonathan tree. In other words, one gallon of spray liquid ordinarily is necessary for each box of apples that any particular tree is capable of bearing.

INCREASING THE DEPOSIT.—The addition of mineral oil or fish oil accomplishes two things in codling moth control. First, more spray material actually is retained on the surface of the apples, as indicated by hundreds of chemical analyses. Second, the spray is held in a smooth film, uniform over the entire surface, leaving little opportunity for entrance of worms.

USE OF MINERAL OIL.—Mineral oil applied when numerous eggs are present serves also as an ovicide and so is particularly valuable in the early cover sprays. Where a dormant application of oil has been used, the mineral oil-lead arsenate combination is often applied. Danger of foliage injury prevents the general use of this combination following lime sulphur, especially when applied as a delayed dormant spray. With mineral oil the lead arsenate dosage may be cut down to two pounds to 100 gallons of water.

USE OF FISH OIL.—Fish oil has also some value as an ovicide, but not as much can be used because of probable injury to foliage and fruit. Fish oil is used at a maximum of one quart to 100 gallons of water. In fact, good results have been obtained with one-half pint to 100 gallons. Cutting down the fish oil to one pint decreases the arsenic deposit some 10 or 15 per cent. Fish oil was used in large quantity in the Wenatchee district in 1933 but most growers used three pounds of lead arsenate instead of two, although only a pint of fish oil generally was added to 100 gallons of water.

LEAD ARSENATE-FISH OIL.—Lead arsenate 2–100 with herring oil one quart was used in six cover sprays on a block of Jonathans in 1932 with good control, as compared with a near-by check block where two pounds of lead arsenate were used without fish oil. As a matter of fact, there were nearly twice as many worms in the straight lead arsenate plot as compared to the same quantity of lead arsenate used with herring oil, 41.4 worms per 100 apples in one case, 23.3 in the other.

Average deposits of arsenic made following the various cover sprays were about the same in these two plots, 94 micrograms per square inch where fish oil was used and slightly less where no fish oil was added. According to analyses at harvest, however, there was a greater tenacity exhibited in the deposit on the lead arsenate-herring oil sprayed trees. In this case there was .084 grain of arsenic per pound and in the lead arsenate check 2–100, .062 grain per pound. Where lead arsenate 3–100 was used on Jonathans, the arsenic deposit was .081 grain per pound.

No special difficulties have been encountered in washing fruit sprayed with lead arsenate and fish oil, but it has often been necessary to utilize a sodium silicate washing solution in order to bring the lead residue down to meet the requirements of the Food and Drug Administration for 1933. Because of this difficulty in removal of lead, it is well to hold to two pounds of lead arsenate when fish oil is used, whenever control may be obtained with that amount.

MANGANESE ARSENATE-FISH OIL.—Although previous studies had indicated that calcium arsenate and manganese arsenate generally were less efficient than lead arsenate for codling moth control, it was assumed that lead arsenate was more effective mainly because a greater amount was deposited on the surface of the apples. Accordingly, in our work in 1933 non-lead arsenicals were used with fish oil and other materials tending to build up deposits.

Two blocks of Romes may be compared where the deposit figures are the same—127 micrograms per square inch. One block of trees was sprayed with manganese arsenate 3:100 plus fish oil one quart and may be compared with a check plot which received straight lead arsenate 3:100. Even though the average deposit was identical, there were twice as many worms in the manganese arsenate-fish oil plot. The block of Romes where six cover sprays of manganese arsenate and fish oil were applied showed 22.2 worms per 100 apples at harvest, while the near-by lead arsenate check plot had only 11.8 worms per 100. The fish oil used in this case was dog fish oil, with an iodine number of 125; free fatty acids, 3.25%.

Laboratory studies with manganese arsenate and fish oil indicated even greater differences. Compared with lead arsenate and fish oil in similar quantities there were three times the number of worms penetrating the sprayed fruits.

CALCIUM ARSENATE-FISH OIL.—Where calcium arsenate and herring oil were used on Romes there was some evidence that calcium arsenate may be equal in efficiency to lead arsenate used alone. Unfortunately, though little injury occurred early in the season there was severe burning and yellowing of the foliage at harvest.

In this comparison an average of three analyses showed a deposit of 144 micrograms per square inch, which we may compare with an average deposit of 127 micrograms where straight lead arsenate was used. In the Romes sprayed with calcium arsenate and herring oil there were 14.3 worms per 100 apples, in the lead arsenate check trees, 16.4. Pacific Coast herring oil was used, with an iodine number of 135; free fatty acids, 1.75%.

In the laboratory, however, twice as many worms penetrated apples sprayed with calcium arsenate and fish oil as compared to lead arsenate and fish oil. The improvement in control realized when fish oil is added to lead arsenate did not materialize when calcium arsenate was combined with fish oil.

CALCIUM ARSENATE-MINERAL OIL—Where mineral oil was used with calcium arsenate at half the usual concentration of summer oil (two quarts to 100 gallons) on Romes, a high deposit resulted and a degree of control even better than straight lead arsenate was obtained. Although a deposit of 156 micrograms per square inch accompanied the use of the calcium arsenate-mineral oil combination, the better control obtained likely is more due to the ovicidal effects of the mineral oil throughout the season than to the high arsenic deposit. In this case on Romes there were 7.9 worms per 100 apples at harvest while on Jonathans sprayed in the same fashion there were 14.1 worms per 100, also better than straight lead arsenate. This may be compared to the plot of trees in which herring oil was used with calcium arsenate and where there were 14.3 worms per 100 apples, nearly twice as many as where mineral oil was used.

The arsenic residue on this fruit was well below the tolerance following treatment with hydrochloric acid 1.5 per cent over rollers at 110° F. No test for lead residue was made, since calcium arsenate was used in the six cover sprays. It is questionable whether apple trees can be subjected to so many applications of mineral oil during the season, even at half the usual concentration.

HIGH DEPOSITS DIFFICULT TO REMOVE.—While it is necessary to build up fairly high deposits of arsenic in order to secure adequate worm control, this may be carried to an extreme because of the difficulty in reducing both lead and arsenic to meet Federal tolerances. In fact, the use of lead arsenate alone has led this year on occasion to high lead residues difficult to remove with ordinary methods.

One particularly tenacious spray schedule very difficult to remove was encountered in 1933, when a block of McIntosh trees in the experimental orchard was sprayed with a combination of lead arsenate three pounds, mineral oil three-fourths gallon, to which was added oleic acid one-fifth pint. Emulsification of the oil was accomplished by adding eight-tenths ounce of sodium silicate. After four cover sprays there was a deposit of 94 micrograms on the McIntosh apple, sufficient to hold the worms in check for the rest of the season, and at harvest our counts indicated only 7.4 worms per 100 apples. These McIntosh apples were approximately 50 per cent wormy in 1932.

On certain of these McIntosh trees two more cover sprays were applied: lead arsenate three pounds, dogfish oil one quart, emulsified with oleic acid and sodium silicate. Applications of these two additional cover sprays built up a high deposit which even at harvest amounted to 220 micrograms and further reduced the infestation on the e trees to 4.5 worms per 100 apples.

These McIntosh apples were cleaned only with great difficulty, resisting both acid and alkaline washes at temperatures so high that considerable injury resulted to the fruit. The lead load was high in the case of both these plots, amounting to .158 grain per pound where the spraying was stopped after the fourth cover and running as high as .485 grain per pound where two additional sprays were applied. High loads of this kind may be practically impossible to remove.

SPREADERS.—Still another means of building up a deposit is by the use of an improved type of spreader. In the earlier work with spreaders investigators found that the use of such materials as calcium caseinate actually reduced the deposit on the apples, although a film type of cover generally resulted.

Due to the improvement of some of these commercial materials high deposits may be obtained when certain colloidal spreaders are used with lead arsenate. Consequently, a uniform cover may be obtained with no loss in deposit. So far, however, it has been necessary to use three pounds of lead arsenate in order to attain a deposit with these commercial spreaders sufficient for effective control under conditions of heavy infestation.

The great advantage in the use of a spreader is in the uniform deposit. No less important, however, is the freedom from residue removal complications when the fruit is washed, a factor which may be of utmost importance, especially in the late cover sprays for second brood, following early applications in which special effort has been made to apply mineral oil-lead arsenate sprays at the peaks of egg deposition.

SOAPS.—Many apple growers have added soaps of various kinds to lead arsenate in order to produce a smooth, uniform type of cover. Where used in this manner only small quantities of soap should be added, usually not more than one-half pound to 100 gallons. Analyses have shown that the addition of larger amounts results in a reduction in deposit. As a matter of fact in some cases it has been possible to cut down the amount of soap to three ounces in 100 gallons and still obtain uniform coverage and a fairly high deposit. Because of the small amount of soap which can be used without resulting in a reduction in deposit, there is very little value in the soap as an insecticide. Much has

been claimed for some of these soaps as insecticides but it is impossible to use any soap in large enough quantity to serve as an insecticide without vastly reducing the amount of lead arsenate deposited on the surface of the apples.

Occasionally growers have become enthusiastic over the use of soap and apply three or four pounds to a hundred gallons of spray material, presumably on the theory that if one-half pound is good, several times that amount will be far better. Actually it does not work out that way. Where soaps have been used as spreaders and no special difficulties have been encountered with residue removal, it is quite possible that further investigation may develop a neutral soap which will be very useful in producing a uniform cover and actually increase the deposit over that usually obtained with lead arsenate alone.

Calcium Arsenate-Soap.—Toxicity to codling moth in any arsenical very evidently is more than a matter of the protection of apples by building up a high arsenic deposit. In one case where three ounces of a special neutral soap[2] was added to calcium arsenate 3–100, an average deposit of 170 micrograms was obtained, yet the worms easily penetrated this deposit to the extent of 46 per 100 apples. Regardless of high arsenic deposit and a uniform type of cover, calcium arsenate failed to stop the worms.

Where soaps or colloidal spreaders have been used with lead arsenate, there has been no difficulty in meeting the new Federal tolerance either on lead or arsenic. Apparently this statement is true of both acid and alkaline washes.

Deposit and Apple Varieties.—In general the higher the deposit on the surface of an apple, other factors being equal, the more efficient is the control. However, varietal differences in susceptibility to worm attack may modify this, as shown in the experimental orchard at Wenatchee in 1933. The arsenic deposit on four varieties sprayed with lead arsenate 3–100 for six cover sprays was measured and is correlated with the wormy fruit at harvest.

Winesaps retained the most arsenic per square inch, with 160 micrograms; Jonathans second, with 156; Delicious third and Romes fourth with 132 and 125 micrograms respectively. The relative small size of Winesaps and Jonathans, as compared to Delicious and Romes, may account for this difference in deposit, since there is greater increase in size in the larger apples.

Control was best on the Winesaps, where there was the highest

[2]Prepared by C. D. Dolman, Chemist, Wenatchee Valley Traffic Association.

deposit, and only 3.4 worms per 100 apples. Next in order, however, were Romes, which had the least deposit, and 13.1 worms per 100 apples, followed by Delicious with 21.2 and Jonathans with 26.6 worms per 100 apples. As a matter of fact, these three varieties when considered strictly in relation to one another present the paradox of the best control with the least deposit. It is common knowledge in the Northwest that Winesaps are subject to worm attack to a much less extent than most other varieties. It is evident that varietal differences, as well as deposit, must be considered as greatly affecting control.

EFFECTS ON APPLE FOLIAGE OF DIFFERENT ARSENICALS AND FUNGICIDES IN COMBINATION

By C. R. CUTRIGHT, *Associate Entomologist, Wooster, Ohio*

Due to the ruling by the Federal Pure Food & Drug Administration against fruit carrying more than a specified amount of lead, it seems reasonable to suppose that non-lead arsenicals may experience a considerably greater use in coming seasons. If this is to be the case, entomologists and others interested in spraying should proceed at once to collect additional data regarding the performance of such materials, not only in relation to insect control but also as to their injurious possibilities and reactions in combination with different fungicides.

Because of these reasons there was conducted at Wooster, Ohio, during the past season an experiment in which five arsenicals and five fungicides were used in all their 25 possible combinations. The arsenicals were lead, calcium, manganese, zinc and magnesium arsenate, while the fungicides were dry lime sulfur plus lime, flotation sulfur (dry), bordeaux 1–3–50, Coposil (dry), and an experimental copper fungicide which is designated as Fungicide A. A young orchard, 9 years of age and in good condition, was selected for this work. Each treatment was applied to a series of six one-tree plots, these being located at random, one to each block. The blocks were composed of the following varieties: No. 1, Courtland; 2, King David; 3, McIntosh; 4, Wealthy; 5, King David; and 6, Grimes. All of the 25 treatments, therefore, appeared once on all varieties except King David where it appeared twice. Each plot received three applications of spray, these being made on June 10, June 26, and July 18. Soon after the first spray, descriptive notes were made on the condition of each plot, this system of record being continued throughout the season. As the season progressed it became evident that defoliation was the most prevalent, most

definite, and most serious form of injury. For this reason most of the injury records were taken on a basis of defoliation.

Methods of taking defoliation records such as estimates and counting dropped leaves on the ground under the tree have been, in past seasons, entirely unsatisfactory. This year a method has been used in which the

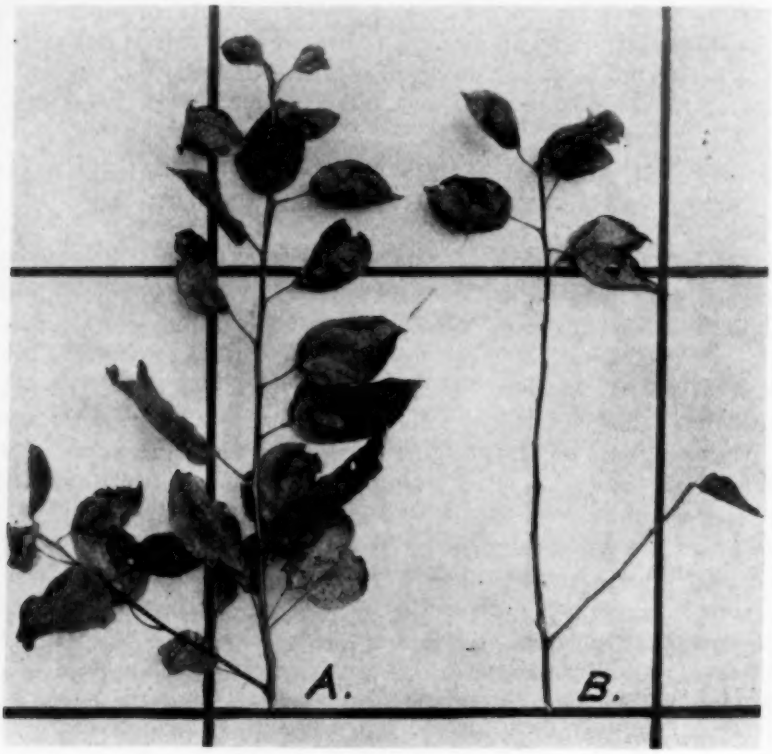


FIG. 24.—(A) Normal terminal. (B) Terminal from tree that has suffered heavy defoliation.

leaves on wood of the current season's growth are considered. (Fig. 24) Leaves about fruit buds and on spurs need not be considered. Defoliation almost always starts with the leaves at the base of the new growth and then proceeds toward the tip of the terminal. As each leaf drops it leaves a record of its former presence in the shape of a definite leaf scar. (Fig. 25) By counting such scars and the remaining leaves that are present on each terminal, an exact record of the defoliation status

may be obtained. By experiment it has been determined that such a count made on 20 terminals of each tree gives an accurate sample.

According to the above method, records were taken on all experimental plots during the last week in August. The results of this count are expressed in a summarized form in the following table. In order to properly evaluate the results it must be remembered that each figure in the main table is the average of six plots and that each mean expressed at the right and at the bottom is the average of 30 plots.

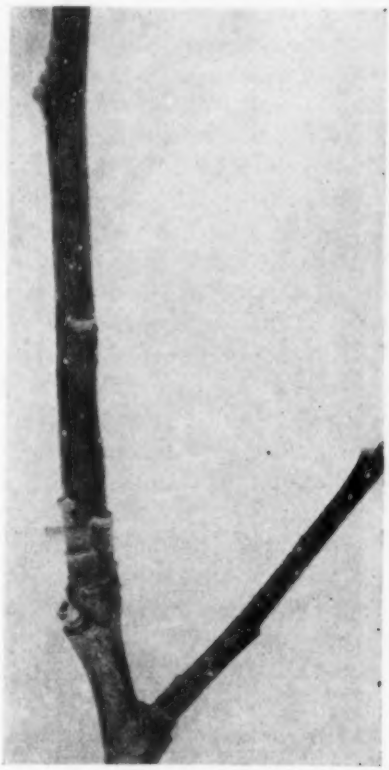


FIG. 25.—Base of defoliated terminal showing leaf-scars.

From these figures we may now consider defoliation as influenced 1st by the arsenical, 2nd by the fungicide, and 3rd by the different combinations.

From the column of means at the right side of the table we find that a range of 12 percentage points exists between high and low materials. By analysis of variance it was determined that approximately a 9 point difference is necessary to obtain 20–1 odds. It is, therefore, apparent that a significant difference in defoliation is due to the arsenical involved, this difference existing specifically between lead and magnesium on one hand and calcium and zinc on the other. There is also quite a range between lead and manganese but the difference can not be proven statistically.

TABLE 1. PER CENT DEFOLIATION

	Lime sulfur lime	Flotation sulfur	Bordeaux 1–3–50	Coposil	Fung. A	Arsenical av.
Lead ars.	14	15	12	13	28	16
Cal. ars.	17	40	12	30	38	27
Mn. ars.	16	37	12	19	36	24
Zn. ars.	21	39	19	33	27	28
Mg. ars.	14	15	12	15	27	16
Fung. av.	16	29	13	22	31	

At the bottom of the table are the fungicide means, and, as in the case of the arsenicals, a 9 point difference is necessary to show significance. Bordeaux and lime sulfur caused the smallest amount of leaf drop, while flotation sulfur and Fungicide A were most injurious. Coposil occupied an intermediate point. The greater range existing between the fungicide means when compared with the arsenical means indicates that the fungicides involved were a greater factor in defoliation than were the arsenicals. This point is further strengthened when we consider the effects of the individual combinations. The main group of figures in the table should now be examined, always keeping in mind that each is the mean of the six replicates. Based on the figures from the 150 individual plots, analysis of variance shows that a difference of 10 points between any of the means indicates a significant difference.

As a detailed discussion of the relationships existing between these means would occupy entirely too much space, the reader can make the individual comparisons that are desired. One or two striking points, however, may be emphasized—the safety of flotation sulfur when used with lead and magnesium arsenate as compared with severe injury when combined with calcium, manganese, and zinc arsenate. Similarly the safety of Coposil used with lead, manganese, and magnesium is striking when contrasted with its injurious effects in combination with calcium and zinc arsenate. The uniformly severe injury experienced with Fungicide A calls for fundamental changes in its manner of use or its manufacture or both.

As the blocks containing the various treatments were composed each of a single variety, an opportunity was afforded to observe the varietal susceptibility to the sprays, both individually and collectively. Defoliation occurred on the varieties in the following order: McIntosh, 16%; Wealthy, 20%; King David, 23%; Courtland, 25%; Grimes, 25%; and King David, 26%. A difference of 5 points is necessary for significance.

Incidentally the control of codling moth in terms of per cent of injured fruit for the experiment was lead arsenate, 5%; zinc, 6%; calcium, 6%; manganese, 7%; and magnesium, 18%. The differences between lead, zinc, calcium, and manganese are, of course, not significant.

SOME COMPARISONS BETWEEN CALCIUM ARSENATE AND LEAD ARSENATE AS GENERAL INSECTICIDES FOR APPLE[1]

By P. J. CHAPMAN, G. W. PEARCE, R. W. DEAN, and O. H. HAMMER, *New York State Agricultural Experiment Station, Geneva, N. Y.*

For many years acid lead arsenate has been the standard stomach insecticide applied to apple trees. This position is still maintained with modifications. Recently, however, a number of other materials have been tested in an effort to find an insecticide which would equal or excel lead arsenate in efficiency, particularly against codling moth, and that would not contain those elements against which legal restrictions have been placed.

The present interest in calcium arsenate and arsenicals other than lead arsenate is, of course, the result of the fixing in 1933 of a lead tolerance by the Federal Food and Drug Administration and the implication made by this agency that no tolerance would be desirable. This article describes some comparisons which have been made between lead and calcium arsenate during the past four seasons, but principally in 1933, under conditions existing in the Hudson Valley and Lake Champlain fruit districts of New York. In these areas the codling moth and apple maggot are the important late-season pests. Growers rarely apply sprays later than July 15 to 20.

COMPARATIVE EFFICIENCY.—The literature contains references, too numerous to mention here, to field and laboratory experiments in which comparisons have been made between these two arsenicals against the pests of apple and those of many other plants. Most experiments indicate that lead arsenate was the more efficient insecticide. Greater solubility in the insect's digestive tract (7), additional insecticidal action supplied by lead which, according to several authors (2, 4, 12) is not possessed by calcium, and greater adhesiveness to plant foliage are the principal explanations advanced for this difference. The variable constitution of "calcium arsenate" (2, 8) has mitigated against precise experimentation.

The apparent susceptibility of various insect pests to the two arsenicals varies considerably. One seems to gain the impression from the literature that differences in favor of lead arsenate were most pronounced when used against certain lepidopterous larvae. Against fruit flies (*Trypetidae*) and adult coleopterous feeders, especially the Mexican cotton boll weevil, differences were slight or appeared to favor

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 29, Jan. 23, 1934.

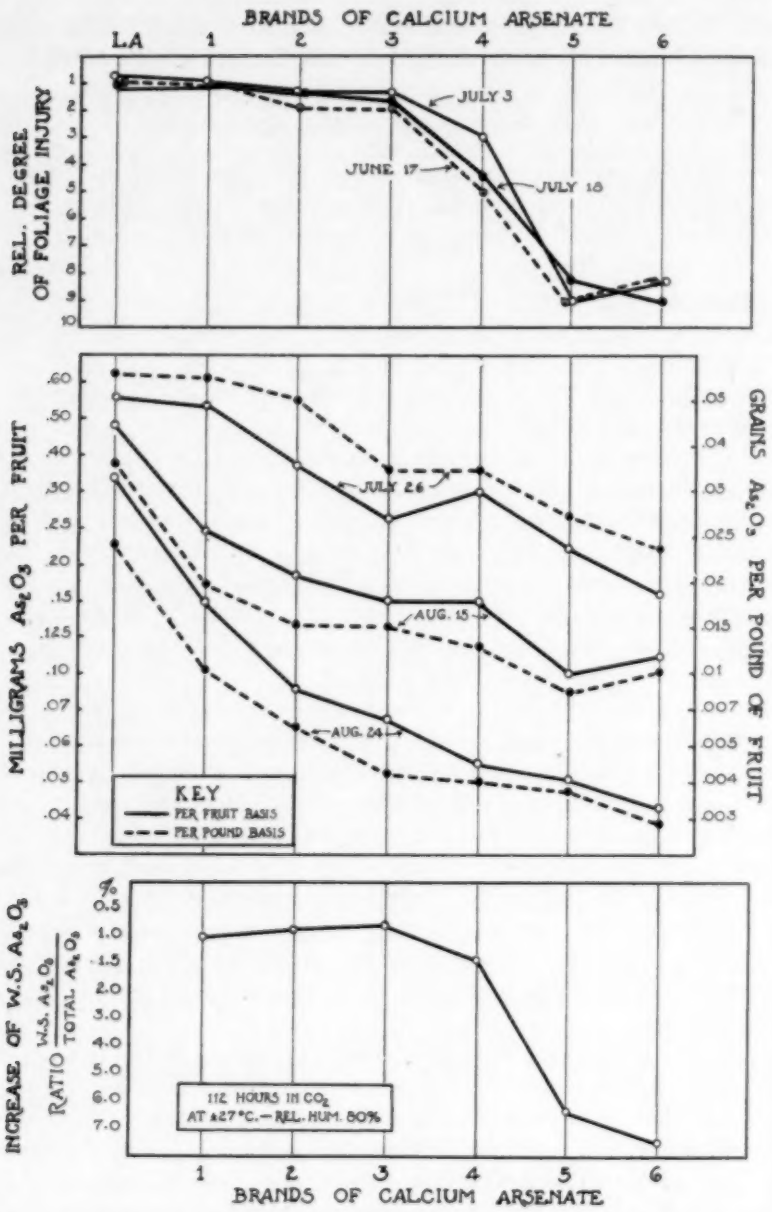


FIG. 26.—A correlation between degree of foliage injury, rate of arsenic loss from spray deposits and amount of carbonation, of six commercial calcium arsenates and lead arsenate.

calcium arsenate. Some data on the comparative efficiency of the two arsenicals are given in Tables 1 and 2.

The data in Table 2 indicate that calcium arsenate and lead arsenate were about equally effective against the apple maggot (*Rhagoletis pomonella*). Other experiments indicate that calcium arsenate is perhaps not quite so dependable as lead arsenate when the minimum number of sprays (i.e. two) have been used—probably due to a loss of protection thru more rapid weathering.

TABLE 1. EFFICIENCY OF THE ARSENATES OF LEAD, CALCIUM AND MAGNESIUM AGAINST CERTAIN APPLE PESTS. ORCHARD EXPERIMENTS 1932–33

				Percentage of fruit infested			
Orchard	Treatment*	Number trees examined	Number fruits examined	Codling moth (wormy)	Rose chafer and rose leaf beetle	Plum curculio	Green fruit worm and leaf roller
Phillips	L. A. 3–100	20	50,371	0.3	1.9	1.3	0.3
Phillips	C. A. 3–100	52	117,467	1.3	1.9	1.5	0.3
Phillips	C. A. 3–100 & $Al_2(SO_4)_3$	15	51,324	0.4	1.7	1.4	0.2
Phillips	M. A. 3–100	15	31,821	3.8	4.5	3.7	1.0
Phillips	Control	23	70,725	(a) 13.4	12.7	11.8	1.3
Frick	L. A. 3–100	3	5,041	..	—	6.8	—
Frick	C. A. 3–100	2	4,734	—	—	7.4	—
Frick	Control	3	4,411	—	—	69.7	—
Hosmer	L. A. 3–100	1	557	13.1	—	—	—
Hosmer	C. A. 4–100	2	1,576	42.1	—	—	—
Hosmer	M. A. 4–100	2	1,953	82.2	—	—	—
Hosmer	Control	1	928	(b) 99.5	—	—	—
Osborn	L. A. 3–100	22	20,977	—	—	2.0	0.2
Osborn	C. A. 3–100	10	8,422	—	—	2.2	0.8
Osborn	M. A. 4–100	13	8,046	—	—	6.5	2.8
Osborn	Control	40	23,190	—	—	26.3	5.3
Sleight	L. A. 3–100	4	3,729	0.2	—	6.8	—
Sleight	C. A. 3–100	27	43,273	1.2	—	5.5	—
Sleight	Control	5	4,771	(c) 40.5	—	53.9	—
Totals		260	453,316				

*Each arsenical is referred to by its initial letters and followed by the number of pounds used per 100 gallons of spray.

(a) Two "cover sprays" June 15 and July 5–6, 1933.

(b) Five "cover sprays" Experiment of S. W. Harman in Niagara County, 1933. See Jour. Econ. Ent. 27: 224, 1934.

(c) Three "cover sprays" June 17, July 3 and July 19, 1933.

TABLE 2. EFFICIENCY OF LEAD ARSENATE AND CALCIUM ARSENATE AGAINST APPLE MAGGOT. PERU, N. Y.

Year	Number maggot sprays	Per cent infestation L. A. orchard	C. A. orchard
1929	none	99.0	99.0
1930	3	28.3	28.1
1931	3	6.2	2.7
1932	3	7.1	4.0

Against codling moth (*Carpocapsa pomonella*), good commercial control was obtained with calcium arsenate in the Hudson Valley,

altho lead arsenate proved more efficient. In western New York, under conditions of heavy infestation and where the caterpillars perhaps are showing a greater resistance to poisonous sprays, this difference in efficiency becomes more apparent. No significant differences in efficiency were observed between the brands of calcium arsenate (Sleight orchard, Table 1). The calcium arsenate-lime sulfur-aluminum sulfate mixture gave better codling moth control than other calcium arsenate combinations. A possible explanation is the slower rate of loss of arsenic from the spray deposit (Fig. 28).

Calcium arsenate gave good control of the plum curculio (*Conotrachelus nenuphar*), the rose chafer (*Macrodactylus subspinosus*), and the rose leaf beetle (*Nodonota puncticollis*). Altho the infestation of the green fruit worm (*Grapholitha* sp.) and leaf roller (*Archips argyrospila*) were light, calcium arsenate appeared to compare favorably with lead arsenate against these pests.

Foliage Injury and Variation in Calcium Arsenates.—Calcium arsenate has a reputation for causing injury, under certain conditions, to the foliage of apple. For this reason, principally, it was not officially recommended for use on apples by most experiment stations prior to 1933—exceptions being Nova Scotia and New Hampshire.

Several investigators have noticed differences between commercial calcium arsenates with respect to their safeness to plant tissues (1, 5). Injury from the use of calcium arsenate is believed to be due to the formation of water-soluble arsenic thru the action of carbon dioxide and water liberated by the leaf or that which may be present in the air or from both sources. The data given in Fig. 26 support this contention and are evidence that differences in relative safety to foliage among commercial calcium arsenates[2] are attributable to the degree to which this action may proceed. Just why such differences should occur is not clear. Since commercial calcium arsenate is a mixture of several calcium- and arsenic-bearing compounds (2, 8), and since 6 or 7 per cent of a sample (8) may consist of calcium hydrate and carbonate, "spreaders", and various impurities, differences may eventually be explained largely on chemical grounds. Variations in the physical characteristics of the calcium arsenate particle are also no doubt involved. It is planned to enlarge on this subject in another paper.

Experimental Procedure.—In the experiments with brands of calcium arsenate, vigorous 12-year-old Baldwin trees were used which

[2]Brands referred to by number only. Included in the test, however, were Niagara, Bowker (Calrox), Sherwin-Williams, General Chemical, Ansbacher, Graselli, and Corona.

yielded an average of about 1,500 fruits per tree in 1933. Each plat consisted of four trees. The controls included plats receiving no spray, one receiving the fungicide alone, and a plat of acid lead arsenate and the fungicide. Details of the treatments are given in Table 3.

TABLE 3. TREATMENTS APPLIED IN THE CALCIUM ARSENATE BRANDS EXPERIMENT, 1933

Name of treatment	Date applied	Spray mixture used*		
		Calcium or lead arsenate	Fungicide	Hydrated lime
Delayed dormant	April 27	———	LS 2–100	———
Pink	May 8	3–100	LS 2–100	3–100
Calyx	May 20	3–100	FS 5–100	3–100
Curculio	May 29	3–100	FS 5–100	3–100
Codling moth	June 19	3–100	FS 5–100	3–100
First apple maggot	July 3	3–100	FS 5–100	———
Second apple maggot	July 19	3–100	FS 5–100	———

*LS = liquid lime-sulfur, FS = flotation sulfur, a wettable elemental sulfur manufactured by the Koppers Company. The number of pounds (gallons in the case of lime and sulfur) added to each 100 gallons of spray is indicated.

OBSERVATIONS ON INJURY.—Two kinds of leaf injury became evident, *viz.*, a uniform yellowing of the leaf and a spot or marginal browning.

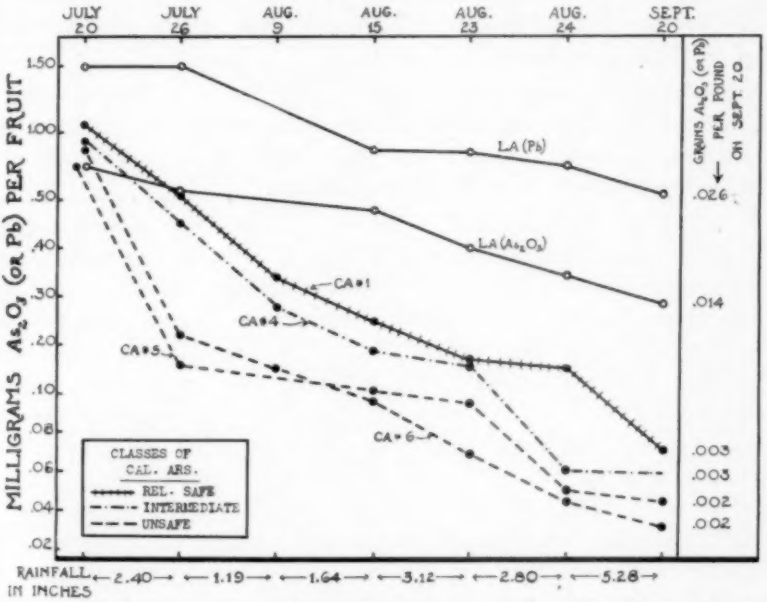


FIG. 27.—Weathering of arsenic and lead from spray deposits of lead arsenate and four brands of calcium arsenate. Baldwin fruits 1933.

Injury estimates were based almost entirely on the abundance of yellow leaves on the tree. In expressing the degree of injury at any given time

the writers used an arbitrary scale of values ranging from 1 to 10. The fungicide and complete check trees were assigned a value of 1 and the plat showing the most injury 10. The relative position of each remaining plat on the scale thus defined was then estimated. Opportunities for taking injury records were seldom longer than of 2 or 3 days duration because the leaves soon dropped after they became yellow and during these partial defoliations the leaves did not, of course, turn yellow and drop simultaneously. A crop of yellow leaves occurred in three instances during the interval between spray applications, or about 2 weeks following the treatment apparently responsible for the injury. The consistency in behavior of the brands is indicated from the data in Fig. 26. In two of the three records reported here three persons took data independently, and in no instance was there a variation greater than one value from the average rating. With the omission of lime from the spray formula in the last two sprays some yellow leaves became evident by August 21 in all calcium arsenate plats. After this time some of the leaves with dead spots or margins turned yellow and dropped, especially where the less safe brands had been used; and by September 30 the general abundance and health of the foliage was very much as is indicated by the earlier scoring in Fig. 26.

Fruit Residue Analysis.—In selecting fruits for analysis, 10 fruits of uniform size and representing as nearly as possible the average—not the maximum—spray residue were used. The Bromate method (13) was employed for the arsenic determinations.

Carbonation Experiments.—The data given in Fig. 26 regarding the increase in water-soluble arsenic when calcium arsenate is exposed to CO_2 under controlled conditions are typical of those obtained in several similar experiments. In this instance samples of approximately 1 mg. of calcium arsenate were weighed on a watch-glass and placed in a dessicator containing H_2SO_4 of a 1.174 density (rel. hum. 80%). The air was exhausted to 50 mm. of mercury by means of a vacuum pump and CO_2 was introduced until the pressure was approximately atmospheric. The desiccator was then placed in a temperature-control cabinet at 27° C for 112 hours. At the end of this time the sample was placed in distilled water for 24 hours and the As_2O_5 in solution was determined by an application of the Bromate method. The total As_2O_5 having varied from 39.5 to 43.5 per cent in the several brands, the percentage of water-soluble arsenic is expressed as the ratio of water-soluble As_2O_5 to total As_2O_5 found. The initial amount of water-soluble arsenic in all brands was negligible.

BASIS FOR EXPRESSING AMOUNT OF SPRAY DEPOSIT.—In showing the amount of arsenic and lead lost from spray deposits on growing fruit the writers have chosen to express the data on the basis of milligrams per fruit. This eliminates such extraneous complications as growth and, to a certain degree, size variation. That variation in size of fruit within the sample and between samples may introduce a large error is indicated from data given in Table 4. In this instance fruits of three sizes were picked for analysis from the same tree, the same day, and the resulting data are presented on three of several possible bases.

TABLE 4. SIZE AS A FACTOR IN EXPRESSING SPRAY RESIDUE ANALYSES. BALDWIN APPLES FROM SLEIGHT EXPERIMENT, AUGUST 23, 1933*

Volume per fruit cubic centimeters†	Calculated diameter per fruit inches‡	Grains of lead		
		Per apple	Per pound	Per square decimeter of surface
53	1.85	.0114	.1042	.0167
	Relative value	82	100	100
99	2.25	.0136	.0770	.0132
	Relative value	99	74	79
158	2.60	.0138	.0466	.0097
	Relative value	100	45	59

*Each analysis based on a 10-fruit sample.
†Determined by displacement in water.
‡Calculated from formula $D = \sqrt[3]{\frac{6v}{\pi}}$. The fruits assumed to be spherical.

If weight or any given unit of surface area are used as bases, differences in a series of analyses are obviously not due to loss of residue alone but loss plus growth. By using the weight or surface area of the *initial series* of samples as a basis, growth could be removed from the calculations.

It should also be pointed out that the "loss" of residue attributable to growth is not a constant, but is dependent upon which manifestation of growth is used as the basis for calculation. For example, the Baldwin fruit (80 fruit samples) in the calcium arsenate brands experiment between July 19 and September 20 increased 45 per cent in diameter, 115 per cent in surface area, 200 per cent in weight, and 215 per cent in volume. Streeter, *et. al.* (10) have pointed out that approximately 40 per cent of the arsenate of lead on harvested fruits occurs in the calyx and stem ends of apples sprayed according to New York schedules. For this reason objection may be raised to use of surface area units as bases for expressing residues for data of the type reported in this paper because of the implication that the deposit is uniformly distributed over the apple surface.

COMBINATIONS WITH FUNGICIDES AND INJURY-CORRECTIVES.—Practically all foliage sprays applied to apples in New York State contain a fungicide as well as one or more insecticides. Calcium arsenate has been used, therefore, in combination with various fungicides and with fungicides to which so-called "injury-correctives" were added. Most of the tests in this connection were conducted in the Phillips' orchard which contained mature Baldwin, McIntosh, and Rhode Island Greening trees, each mixture being applied to at least three trees of each variety.

EXPERIMENTS IN PHILLIPS' ORCHARD.—Six treatments were applied as follows: "Delayed dormant" on April 26, "pink" on May 5, " "calyx" on May 22, "curculio" on June 2, "codling moth" on June 15, and "apple maggot" on July 5–6. Liquid lime-sulfur 2–100 and nicotine sulfate 1–800 only were used in the delayed dormant spray. The plats received the following treatments:

Plat 2. Arsenate of lead 3–100 liquid lime-sulfur 2–100 pink and calyx sprays, "dry-mix" (300-mesh sulfur 10 pounds, hydrated lime 3 pounds, Goulac 2 pounds in each 100 gallons spray) for remainder.

Plat 3. Calcium arsenate 3–100, otherwise as Plat 2.

Plat 5. Calcium arsenate 3–100, liquid lime-sulfur 2–100 and iron (ferrous) sulfate 7–100.

Plat 6. Calcium arsenate 3–100, liquid lime-sulfur 2–100 and aluminum sulfate 6–100.

Plat 7. Calcium arsenate 3–100, liquid lime-sulfur 2–100 and hydrated lime 9–100.

Plat 8. Magnesium arsenate 4–100, otherwise as Plat 2.

Plat 9. Lead arsenate 3–100 and liquid lime-sulfur 2–100.

Plat 10. Calcium arsenate 3–100 and liquid lime-sulfur 2–100.

Plat 11. Calcium arsenate 3–100 and bordeaux mixture 3–6–100 (formula for Plat 10 substituted for the calyx spray).

The persistence of arsenic in the various spray deposits is shown in Fig. 28. These data are based on samples containing 10 McIntosh fruits each.

A summary of the leaf injury observations is given in Table 5, being an average of readings taken July 3 and September 8. The method used in taking the data was the same as described under the discussion of the calcium arsenate brands experiment. Three observers scored the plats independently at each reading. Very similar scorings resulted.

Injury may be produced either by the fungicide, the insecticide, or by their combination. In Plat 11 typical bordeaux leaf and fruit injury occurred, while in other plats lime-sulfur was undoubtedly responsible

in part for some defoliation. The occurrence of yellow leaves appears to result chiefly from arsenic injury altho lime-sulfur and drought may produce similar effects. The complexities of lime-sulfur, bordeaux mixture, and arsenical (chiefly lead arsenate) spray injury have been summarized recently by Dutton (4).

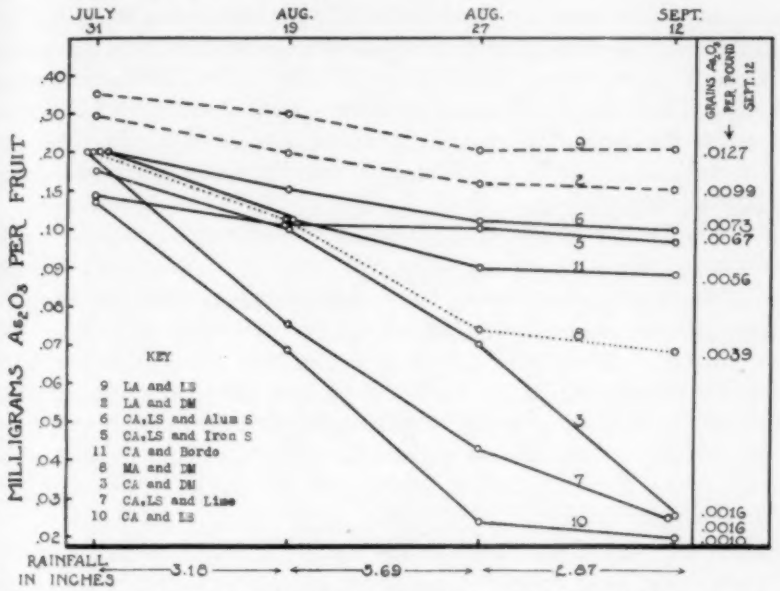


FIG. 28.—Weathering of arsenic from certain insecticide-fungicide spray deposits on McIntosh fruits. Phillips orchard 1933.

The degree of injury is, of course, controlled by many factors, including amount of rainfall and other weather conditions, variety, subterranean and aerial vigor or the tree, set of fruit, heaviness of spraying,

TABLE 5. RELATIVE DEGREE OF YELLOW-LEAF AND LEAF-DROP FROM USE OF COMBINATIONS OF CALCIUM, LEAD, AND MAGNESIUM ARSENATE WITH VARIOUS FUNGICIDES AND CORRECTIVES. PHILLIPS EXPERIMENT 1933

Plat number	McIntosh	Rhode Island Greening	Baldwin	Average
10	2	10	8	6.6
11	3	10	6	6.3
5	3	6	4	4.3
9	2	6	5	4.3
7	2	5	5	4.0
6	2	4	3	3.0
3	2	4	3	3.0
2	2	3	2	2.3
8	1	2	3	2.0
Controls	1	1	1	1.0
Average	2.1	5.5	4.3	

etc. The McIntosh variety was much less sensitive than Greening and Baldwin to all the treatments in the Phillips' experiment (Table 5). Trees with a full set of fruit appeared to sustain less foliage injury generally than trees in their off-bearing year. Injury was likewise more pronounced on trees with subnormal root and leaf systems.

INJURY-CORRECTIVES.—The role and limitations of hydrated lime in suppressing the formation of water-soluble arsenic in spray mixtures containing arsenicals is discussed by Streeter and co-workers (8, 10), among others. Field observations made by the writers substantiate somewhat the claim of these authors that the beneficial effects of calcium hydrate are soon lost thru carbonation with the result that injury may simply be postponed.

Kelsall (5) and others have experimented with the sulfates of iron (ferrous), aluminum, and zinc as injury correctives. Aluminum sulfate proved superior in combination with calcium arsenate and liquid lime-sulfur to either iron sulfate or hydrated lime in the Phillips' experiment. Not only did "yellow leaf" appear in the iron sulfate plat, but a slight black russet appeared on McIntosh fruit, and the fruit of all varieties failed to size or color properly. In the Lake Champlain Valley (Crown Point, N. Y.) a schedule of eight iron sulfate-calcium arsenate-lime sulfur sprays were applied to mature McIntosh and Northern Spy trees with good results. No yellow leaves appeared and the foliage was excellent, altho the fruit ripened unevenly. Over spraying (which is easily done) may account for some of the variable results with this combination.

Calcium arsenate in combination with hydrated lime and various fungicides was used by many Hudson Valley orchardists in 1933, principally in the last one or two sprays. Some growers in cooperative tests applied as many as four or five treatments to small blocks of trees. Serious leaf injury resulted in a few instances, altho in general the growers felt that leaf injury was inconsequential and some saw no ill effects.

SUMMARY.—Calcium arsenate and lead arsenate used on an equal weight basis were about equally efficient against plum curculio, rose leaf beetle, rose chafer, and apple maggot. Lead arsenate gave better control of codling moth and the green fruit worms.

Commercial calcium arsenates vary in safeness. A correlation was found among the brands between the degree of foliage injury, amount of carbonation, and rate of arsenic weathering from spray deposits. No entirely safe brand was found.

Foliage injury records were based principally on the occurrence of yellow leaves; the degree of injury was measured by means of an arbitrary scale of values ranging from 1 to 10.

Hydrated lime added to calcium arsenate sprays tends to suppress arsenical injury, but may simply postpone it.

Aluminum sulfate proved superior to hydrated lime or iron (ferrous) sulfate as an injury-corrective when added to calcium arsenate and liquid lime-sulfur.

Calcium arsenate is less adhesive than lead arsenate. Likewise the rate of arsenic-loss is influenced considerably by the fungicide or injury-corrective present.

McIntosh proved much less sensitive to injury to all insecticide-fungicide combinations than Baldwin, Rhode Island Greening, and Ben Davis.

To eliminate growth and, to a certain extent, variation in fruit size from studies on the weathering of spray residues, data are expressed on the basis of milligrams per fruit.

Literature Cited

1. Coad, B. R., and T. P. Cassidy. Cotton boll weevil control by the use of poison. U. S. Dept. Agr. Bul. 875, p. 3. 1920.
2. Cook, F. C., and N. E. McIndoo. Chemical, physical and insecticidal properties of arsenicals. U. S. Dept. Agr. Bul. 1147. 1923.
3. Dutton, W. C. Spray injury studies I. Injuries from summer applications on apples. Michigan Agr. Expt. Sta. Spec. Bul. 218. 1932.
4. Fink, D. E. Physiological studies of the effect of arsenicals on the respiratory metabolism of insects. Jour. Agr. Res. 33: 993–1007. 1926.
5. Howard, N. F., and F. W. Fletcher. The effect of various commercial calcium arsenates on bean foliage. U. S. Bureau of Ent. paper E-304. 1933. (mimeographed.)
6. Kelsall, A. Some new insecticide-fungicide combinations. Fourth Internat. Congress Ent. Trans. 2: 1–3. 1929.
7. Lovett, A L., and R. H. Robinson. Toxic values and killing efficiencies of arsenates. Jour. Agr. Res. 10: 199–207. 1917.
8. Smith, C. M., and C. W. Murray The composition of commercial calcium arsenate. Ind. and Engr. Chem. Jour. 23: 207–208. 1931.
9. Streeter, L. R., and G. W. Pearce. Reactions involved in the use of hydrates in lead arsenate sprays. Ind. and Engr. Chem. Jour. 23: 1140. 1931.
10. ————, et al. Spray and other deposits on fruit. New York Agr. Exp. Sta. Bul. 611: 5. 1932.
11. ————. The adherence of copper dusts to foliage.' Phytopath. 22: 649. 1932.
12. Walker, H. W., and J. E. Mills. Progress report of work of the chemical warfare service on the boll weevil. Jour. Econ. Ent. 19: 600–601. 1926.
13. Report on metals in foods. Assoc. Official Agr. Chem. 16: 75–77. 1933.

BENTONITE COMPOUNDS AS AGENTS FOR THE RETENTION OF NICOTINE ON APPLE FOLIAGE AND FRUIT IN CODLING MOTH CONTROL*

By BYRLEY F. DRIGGERS, *Associate Entomologist*, and B. B. PEPPER, *Research Assistant, New Jersey Agricultural Experiment Station*

In a previous paper[1] the writers presented data from summer spraying experiments on apples which showed that nicotine tannate when used with bentonite sulfur was more effective as a control for codling moth than either the standard lead arsenate spray or lead arsenate when used with summer oil. These results were obtained on the first brood of codling moth when the different materials were applied the same number of times as well as on second brood when the nicotine tannate was used more often than the standard spray. On less extensive block tests nicotine sulfate with bentonite sulfur and soap, and nicotine sulfate combined with bentonite and soap without sulfur, gave controls of codling moth which were superior to the standard lead arsenate treatment. Data were also presented which showed that nicotine tannate with bentonite sulfur used on a 7-day schedule on second brood was more effective than nicotine tannate alone on a 7-day schedule. It appeared that the bentonite sulfur or the bentonite was operating in the field to make the nicotine tannate and the nicotine sulfate toxic to codling moth larvae over a longer period of time than would be the case were these materials applied alone. It was thought that the bentonite sulfur, or the bentonite, brought about this increased toxicity either by fixing the nicotine more firmly chemically or by sticking the materials to the fruit and foliage more firmly physically or possibly by both of these processes. It was known from previous work that bentonite possessed the property of "fixing" nicotine. It was also known that bentonite sulfur tended to adhere more firmly to the fruit and foliage of apple than many of the common spray materials used in spraying apples.

Experiments were run to determine by analysis of foliage whether the bentonite sulfur when used with nicotine tannate or nicotine sulfate caused the nicotine to remain on the tree in larger amounts and over a longer period of time. In addition laboratory experiments were carried on with recently hatched codling moth larvae to determine whether bentonite sulfur added to nicotine tannate would increase or prolong the

*Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

[1]Driggers, Byrley F., and Pepper, B. B. J. Ec. Ent. Vol. 27, pp. 280–288.

toxicity of the nicotine tannate. Doctor H. C. McLean and Mr. A. L. Weber of the Spray Residue Removal Department of this station cooperated by analyzing the foliage for nicotine. The sampling of the fruit and foliage and the biological tests were carried out by the writers.

ANALYSIS OF FOLIAGE FOR NICOTINE.—One of the experimental blocks at Glassboro was sprayed with nicotine tannate[2] and bentonite sulfur four times at ten day intervals during the period first brood codling moth larvae were hatching. It was originally planned to continue spraying this block during second brood with nicotine tannate without bentonite sulfur on a seven day schedule. After the data on first brood codling moth injury on the various blocks were collected and the results showed that the block sprayed with nicotine tannate and bentonite sulfur had more clean fruit than any of the other blocks, it was decided to divide this block and spray one-half during second brood with nicotine tannate alone and continue spraying the other half with nicotine tannate and bentonite sulfur. Since both of these new blocks had been sprayed with bentonite sulfur during first brood there was a possibility that the residue of bentonite sulfur remaining on the block to be sprayed with nicotine tannate would continue to tie up or stick the nicotine tannate. If this happened foliage analysis for nicotine on the two blocks might not show any marked difference. To guard against this possible error two small blocks of two trees each were selected in a Rome Beauty block nearby where no spraying had been done early in the season due to failure of the trees to set a crop of fruit. One of these blocks was sprayed with nicotine tannate and the other sprayed with nicotine tannate and bentonite sulfur at the same time the two large blocks were sprayed during second brood.

Leaf samples were collected from each of the four blocks beginning about the middle of July and continuing into September. Some samples were collected immediately after the trees had been sprayed and had dried off, some at intervals of a week or more after spraying and still other samples were collected after heavy rains. The foliage samples were taken at random using an apparatus developed by Ginsburg[3] which cuts a circular disc of measured area from the center of each leaf. The discs were of such a size that 84 were required to make a square foot of foliage. It was found in preliminary tests that a half square foot of foliage was sufficient for a sample. As soon as the leaf samples were

[2]Nicotine tannate formula: one pint free nicotine (50%) and 3 pints liquid tannic acid (50%) to 100 gallons water.

[3]Ginsburg, J. M. Journ. Agr. Res., Vol. 36, No. 12, pp. 1007–1009.

collected they were placed in jars in a weak hydrochloric acid solution to hold the nicotine until analyzed.

Foliage samples were taken and analyzed for nicotine on two additional blocks. Both of these blocks were sprayed at intervals of approximately 10 days on June 3, 13, 25, July 7, 17, 28, August 7, 27 and September 8. The first of these blocks was sprayed with nicotine sulfate 1 pint, bentonite sulfur 8 pounds and neutral sulfo-ammonium soap 2 pounds to 100 gallons. The second block was sprayed with a compound supplied by the Tobacco By-Products and Chemical Corporation known as formula 155. This product contained bentonite, nicotine sulfate and soap in the same amounts as used in the first block. Foliage samples were collected from these two blocks during August and part of September in the manner already described to see if there was any difference in the amount of nicotine retained by the two materials.

During the time the different sprays were being applied and the foliage samples taken, it was desirable to have a record of the rainfall. Unfortunately no gauge for measuring rainfall was available for use, therefore, daily notes on rainfall were kept.

The results obtained from the foliage analysis on the six blocks are set forth in Tables 1, 2 and 3.

TABLE 1. RELATIVE AMOUNTS OF NICOTINE ON A SQUARE FOOT OF STAYMAN FOLIAGE ON BLOCK 1 (SPRAYED WITH NICOTINE TANNATE) AND BLOCK 2 (SPRAYED WITH NICOTINE TANNATE AND BENTONITE SULFUR)

Dates of spraying	Dates of sampling	Mgm. nicotine Block 1	Block 2	Notes on weather
July 21	July 28	7.11	11.00	Showers day and night of July 26
July 28	July 28	14.32	15.96	
July 28	Aug. 4	3.14	6.17	Heavy rains night of Aug. 3
Aug. 4	Aug. 4	12.52	13.38	
Aug. 4	Aug. 11	7.63	12.08	Rain afternoon and evening of Aug 10
Aug. 4	Aug. 15	5.35	10.71	Shower afternoon of Aug. 13
Aug. 15	Aug. 16	10.39	14.36	Rains 11:00 A.M. to 2:00 P.M., Aug. 14
Aug. 15	Aug. 19	1.43	13.56	Rain morning of Aug. 17
Aug. 15	Aug. 24	1.20	13.68	Shower at noon Aug. 18
Aug. 28	Aug. 28	5.40	15.96	Heavy rains and storms Aug. 20 to Aug. 23
Aug. 28	Aug. 31	6.38	11.85	
Aug. 28	Sept. 4	3.19	7.31	Rain afternoon and evening Aug. 28
Aug. 28	Sept. 8	2.50	8.48	Shower at noon Sept. 1
Average nicotine per sample.....		6.20	11.20	Showers Sept. 3, Sept. 4.

DISCUSSION OF RESULTS.—The data in Table 1 show a marked retention of nicotine on the foliage when bentonite sulfur was used with nicotine tannate. The average milligrams of nicotine per sample for 14 samples on each block was 6.20 for block 1 (nicotine tannate) and 11.20 for block 2 (nicotine tannate and bentonite sulfur). The bentonite sulfur added to the nicotine tannate spray brought about the retention

TABLE 2. RELATIVE AMOUNTS OF NICOTINE ON A SQUARE FOOT OF ROME BEAUTY FOLIAGE ON BLOCK 3 (SPRAYED WITH NICOTINE TANNATE) AND BLOCK 4 (SPRAYED WITH NICOTINE TANNATE AND BENTONITE SULFUR). BLOCKS RECEIVED NO SPRAYS PREVIOUS TO JULY 14

Dates of spraying	Dates of sampling	Mgm. nicotine Block 3	Block 4	Notes on weather
July 14	July 14	3.60	4.10	
July 14	July 17	2.21	3.21	Heavy rain 5 to 11 A.M., July 16
July 21	July 21	4.15	4.10	
July 21	July 28	2.05	4.63	Showers day and night of July 26
July 28	July 28	3.53	7.18	
July 28	Aug. 4	1.60	5.32	Heavy rains night of Aug. 3
Aug. 4	Aug. 4	5.01	10.26	
Aug. 4	Aug. 7	3.42	5.83	
Aug. 4	Aug. 11	1.71	8.04	Rain afternoon and evening of Aug. 10
Aug. 4	Aug. 15	2.00	2.92	Shower afternoon of Aug. 13
Aug. 15	Aug. 16	6.31	11.30	Rains 11 A.M. to 2 P.M., Aug. 14
Aug. 15	Aug. 19	1.02	3.65	Rain morning of Aug. 17
Aug. 15	Aug. 24	1.08	2.05	Shower at noon Aug. 18
Aug. 28	Aug. 28	2.02	5.81	Heavy rains and storms
Aug. 28	Aug. 31	1.60	6.27	Aug. 20 to Aug. 23
Aug. 28	Sept. 4	1.60	6.27	Rain afternoon and evening Aug. 28
Aug. 28	Sept. 8	1.28	4.44	Shower at noon Sept. 1
Aug. 28	Sept. 12	1.00	2.28	Showers Sept. 3, Sept. 4
Aug. 28	Sept. 16	Trace	2.73	Showers Sept. 11, Sept. 12
Aug. 28	Sept. 20	None	3.42	Rain day and night, Sept. 14
Aug. 28	Sept. 24	None	2.28	Rains all day Sept. 15, Sept. 16
Aug. 28	Sept. 29	None	1.14	Showers Sept. 19, Sept. 21, Sept. 23
Average nicotine per sample.....		2.05	4.87	Hard rain Sept. 28

TABLE 3. RELATIVE AMOUNTS OF NICOTINE ON A SQUARE FOOT OF STAYMAN FOLIAGE ON BLOCK 5 (SPRAYED WITH BENTONITE, NICOTINE SULFATE AND SOAP) AND BLOCK 6 (SPRAYED WITH BENTONITE SULFUR, NICOTINE SULFATE AND SOAP)

Dates of spraying	Dates of sampling	Mgm. nicotine Block 5	Block 6	Notes on weather
July 28	Aug. 4	1.14	7.52	Showers day and night of July 26
July 28	Aug. 7	1.18	4.71	Heavy rains night of Aug. 3
Aug. 7	Aug. 7	7.06	9.57	
Aug. 7	Aug. 11	3.64	6.74	Rain afternoon and evening of Aug. 10
Aug. 7	Aug. 15	2.20	3.87	Shower afternoon of Aug. 13
Aug. 7	Aug. 19	2.09	2.10	Rains 11 A.M. to 2 P. M., Aug. 14
Aug. 7	Aug. 24	0.98	1.58	Rain morning of Aug. 17, Aug. 18
Aug. 26	Aug. 28	3.53	5.06	Heavy rains and storms
Aug. 26	Aug. 31	1.25	4.33	Aug. 20 to Aug. 23
Aug. 26	Sept. 4	2.62	2.96	Rain afternoon and evening, Aug. 28
Aug. 26	Sept. 8	0.50	3.33	Showers at noon Sept. 1
Average nicotine per sample.....		2.38	4.71	Showers Sept. 3, Sept. 4

of nearly twice as much nicotine as was found when the nicotine tannate was used alone. If we examine the individual analyses, we find that at the beginning of the experiment those samples taken on the same day and immediately after the blocks were sprayed showed high amounts of nicotine in block 1 as well as block 2. The bentonite sulfur residue from the earlier sprays on block 1 no doubt continued to tie up the nicotine for

a time. The nicotine was lost more rapidly and to a greater degree on block 1 than on block 2, particularly after rains.

It so happened that the data in Table 2 was unnecessary. However, the data in this table serves to confirm and strengthen the data in Table 1. Here again block 4 sprayed with nicotine tannate and bentonite sulfur averaged twice as much nicotine per sample as block 3 sprayed with nicotine tannate alone. Following the last application on these two blocks on August 28, samples of foliage were taken and analyzed from each block every three or four days for a period of one month. Only a trace of nicotine could be detected on block 3 at the end of twenty days whereas there was an appreciable amount of nicotine on block 4 after 32 days.

The data in Table 3 show that more nicotine was retained on block 6 sprayed with tank mixed bentonite sulfur, nicotine sulfate and soap than was retained on block 5 sprayed with formula 155 (bentonite, nicotine sulfate and soap combined before adding to the tank in the form of a powder). These analyses agree with our observations through the season that after rains more residue was noticeable on the foliage of block 6 than on block 5.

Insectary Tests with Codling Moth Larvae.—A third method used to determine whether nicotine tannate with bentonite sulfur was more effective than nicotine tannate alone was to run insectary tests with these two mixtures using codling moth larvae as the test insect. The procedure was as follows: Half grown apples from the college farm orchard were secured and all lead arsenate residue removed by washing in "Vatsol" and hydrochloric acid. Half of the lot of apples was dipped in nicotine tannate spray (formula: 1 pint free nicotine (50%) and 3 pints liquid tannic acid (50%)). The other half was dipped in a similar batch of nicotine tannate spray to which had been added bentonite sulfur at the rate of 8 pounds to 100 gallons of spray. As soon as the apples were dry eight were taken from each lot, cords attached to the stems and each apple suspended immediately above a jelly glass having a diameter a little larger than that of the apple. The purpose of the jelly glass was to catch any larvae that might die on the surface of the apple and become dislodged. Approximately ten codling moth eggs in the so-called black spot stage were placed with a section of apple leaf on each apple. After two or three days had elapsed the apples were examined for live and dead larvae. Eight apples were again taken from each lot and soaked for five minutes in well water and the water poured off. After the apples had dried they were suspended above jelly glasses and larvae added in the same manner as outlined before. The remaining

apples in the two dipped lots were suspended by cords in trees near the insectary to determine the effect on toxicity of exposure to weather. Eight apples were brought into the insectary from each lot at the end of five, ten and twenty days. The procedure followed with these lots from the time they were brought into the insectary was the same as described for the first two lots. Table 4 sets forth the treatments the different lots received, the number of larvae used in each lot of 8 apples, the number of larvae dead and missing, and the percentage of larvae dead. Apples which had been washed so as to remove all lead arsenate residue were used as checks to determine the natural larval mortality and loss.

TABLE 4. RELATIVE KILL OF LARVAE PLACED ON APPLES DIPPED IN (1) NICOTINE TANNATE AND (2) NICOTINE TANNATE AND BENTONITE. EIGHT APPLES IN EACH LOT

Lot No.	Treatment before larvae were added	Total larvae used	Number larvae Missing	Live	Dead	Larvae dead %
1	Check	91	8	80	5	5.5
2	Dipped in nicotine tannate	91	30	27	34	37.3
3	Dipped in nicotine tannate and bentonite sulfur	84	26	21	36	42.8
4	Dipped in nicotine tannate, soaked in water for 5 minutes	97	14	68	16	16.5
5	Dipped in nicotine tannate and bentonite sulfur, soaked in water 5 minutes	91	28	46	17	18.7
6	Dipped in nicotine tannate, hung in tree 5 days	94	26	34	37	39.3
7	Dipped in nicotine tannate and bentonite sulfur, hung in trees 5 days	105	20	27	57	54.3
8	Dipped in nicotine tannate, hung in tree 10 days	85	14	48	23	27.0
9	Dipped in nicotine tannate and bentonite sulfur, hung in tree 10 days	90	9	37	44	48.8
10	Check	92	18	68	6	6.5
11	Dipped in nicotine tannate, hung in tree 20 days	64	7	53	4	6.2
12	Dipped in nicotine tannate, and bentonite sulfur, hung in trees 20 days	34	3	22	9	26.5
13	Check	52	7	44	1	2.0

The data in Table 4 show that in every instance the apples treated with nicotine tannate and bentonite sulfur had a higher percentage of dead larvae than the apples treated with nicotine tannate alone. It is true that some of the differences were not very great. In addition too many larvae were missing which tended to make the results less clear cut. It was observed also that the spray coating obtained by dipping was rather uneven, leaving areas on the apples which were unprotected.

It was decided to repeat the experiment in order to eliminate some of the weak points in the technique. Another lot of green apples were secured and washed to remove any arsenic on the surface. Two lots of

the washed apples were taken to Glassboro where the field spraying tests were being run and one lot suspended in the block being sprayed with nicotine tannate. The other lot was suspended in the block being sprayed with nicotine tannate and bentonite sulfur. The blocks were sprayed with the respective treatments and as soon as the suspended apples were dry they were collected, packed carefully to avoid disturbing the poison coating, and returned to the insectary at New Brunswick. Instead of using 8 apples to a lot the number was reduced to 5. In addition the apples were placed in a square of white paper surrounded with tree tanglefoot to prevent the larvae escaping. The rest of the procedure was the same except for slight variations as was followed in the first experiment. Table 5 sets forth the treatments the different lots received, the number of larvae used in each lot of 5 apples, the number larvae dead and missing and the percentage larvae dead. Checks were run with washed apples to which larvae were added to determine the natural mortality of the larvae being used.

TABLE 5. RELATIVE KILL OF LARVAE PLACED ON APPLES SPRAYED WITH (1) NICOTINE TANNATE AND (2) NICOTINE TANNATE AND BENTONITE SULFUR. FIVE APPLES USED IN EACH LOT

Lot No.	Treatment before larvae were added	Total larvae used	Number larvae: Missing	Live	Dead	Larvae dead %
1	Check	92	18	68	6	6.5
2	Sprayed with nicotine tannate	51	12	17	22	43.1
3	Sprayed nicotine tannate and bentonite sulfur	54	2	7	45	83.3
4	Sprayed nicotine tannate, soaked in water 10 minutes	63	13	27	23	36.5
5	Sprayed nicotine tannate and bentonite sulfur, soaked 10 minutes	51	0	10	41	80.4
6	Sprayed nicotine tannate, hung in tree 5 days	57	8	31	18	31.5
7	Sprayed nicotine tannate and bentonite sulfur, hung in tree 5 days	75	1	18	56	74.6
8	Sprayed nicotine tannate, hung in tree 10 days	63	13	48	2	3.1
9	Sprayed nicotine tannate and bentonite sulfur, hung in tree 10 days	59	10	36	13	22.0
10	Check	52	7	44	1	2.0
11	Sprayed nicotine tannate, hung in tree 20 days	64	7	53	4	6.2
12	Sprayed nicotine tannate and bentonite sulfur, hung in tree 20 days	65	6	48	11	17.0
13	Check	68	11	56	1	1.4

The data in Table 5 show a consistent increase in larval kill where nicotine tannate and bentonite sulfur was used over the kill obtained with nicotine tannate. Forty-three per cent of the larvae placed on the nicotine tannate sprayed apples shortly after spraying (lot 2) were killed as compared to 83 per cent killed on the nicotine tannate and

bentonite sprayed apples (lot 3). After soaking the apples in water ten minutes and then adding the larvae there were 36.5 per cent killed on the nicotine tannate (lot 4) as compared to 80.4 per cent killed on the nicotine tannate and bentonite (lot 5). The weathering effect when the sprayed apples were placed in a tree for 5, 10, and 20 days was more pronounced where nicotine tannate was used than where nicotine tannate and bentonite sulfur was used. After ten days in the field the kill on the nicotine tannate sprayed apples was no greater than the kill obtained on the different check lots. Twenty-two and 17 per cent of the larvae were killed on the nicotine tannate and bentonite sulfur sprayed apples after they had remained outside 10 and 20 days respectively. The apples which were hung in the trees for 10 days were subjected to 2.5 inches of rainfall and those which were outside 20 days were subjected to 6.23 inches of rainfall. In spite of this heavy rainfall the nicotine tannate and bentonite sulfur retained a sufficient amount of nicotine to produce a larval kill considerably higher than the larval kill on the checks.

Summary and Conclusions.—Two blocks were sprayed with nicotine tannate and two with nicotine tannate and bentonite sulfur. A series of foliage samples were collected from each of the four blocks immediately after spraying, after rains and at various intervals after spraying. Seventy-four samples were collected from the four blocks and the nicotine determined. In the series of analyses twice as much nicotine was found on the foliage sprayed with nicotine tannate and bentonite sulfur as was found on the foliage sprayed with nicotine tannate alone. Nicotine was found on foliage sprayed with nicotine tannate and bentonite sulfur 32 days after the last spray application even though heavy rains had occurred during the month previous to the time the foliage was analyzed. Foliage analyses for nicotine were made on a block sprayed with tank mixed bentonite sulfur, nicotine sulfate and soap. Foliage analyses were made at the same time on a second block sprayed with formula 155 (bentonite, nicotine sulfate and soap). A series of eleven analyses of foliage from each of the two blocks showed twice as much nicotine on the block sprayed with bentonite sulfur, nicotine sulfate and soap as was found on the block sprayed with formula 155.

Insectary tests were run with codling moth larvae to determine whether bentonite sulfur added to nicotine tannate spray would increase the toxicity of the nicotine tannate and lengthen the period that the poison coating would remain effective. In two series of tests apples sprayed with nicotine tannate and bentonite sulfur were more toxic

to codling moth larvae than apples sprayed with nicotine tannate alone. Subjecting the apples to outside exposure and soaking them in water showed that the nicotine tannate and bentonite sulfur mixture retained the toxicity to a greater degree and over a longer period of time than the nicotine tannate mixture.

The conclusions drawn from these experiments are: (1) Bentonite sulfur "fixes" and/or "sticks" the nicotine of nicotine tannate and nicotine sulfate to the foliage of apple more firmly than when these two nicotine compounds are used alone. (2) By retaining the nicotine in larger amounts and over a longer period of time bentonite sulfur when used with relatively unstable nicotine compounds prolongs the toxicity of these compounds to codling moth larvae and, therefore, increases the efficiency of these compounds when used as a control for codling moth.

Proceedings of the Fifth Annual Paper Reading Session of the Eastern Branch of the American Association of Economic Entomologists (*Continued*)

FIELD TESTS ON LONG ISLAND OF DERRIS AS AN INSECTICIDE FOR THE CONTROL OF CABBAGE WORMS

By H. C. Huckett, *Riverhead, N. Y.*

As a direct outcome of the arsenical residue situation in the cauliflower industry on Long Island during the fall of 1932, it was resolved to test the effectiveness of derris and pyrethrum as insecticides for the control of cauliflower worms in the hope that these materials might be found effective, as had already been indicated, and furthermore, that they might be available for use at a price sufficient to induce growers to use them in place of arsenicals and as an alternative to the improvised but unpopular method of close trimming the head.

Field Tests of Early Crops.—The materials used consisted of proprietary products, applied so far as possible according to the directions on the package. Sprays were, (1) Hellthspra No. 1[1], composed of derris extractives plus a neutral soap, (2) Pyrethrum basic extract[2], of about 2.1 per cent pyrethrins content, combined with Penetrol in the proportions of one to six by volume respectively, (3) Cubor,[3] a combined concentrate of derris and pyrethrum extractives plus a spreader. Each

[1]Product of Plant Foods, Inc., Blue Point, Long Island.
[2]Product of John Powell and Co., Inc., New York City.
[3]Product of Chipman Chemical Co., Bound Brook, New Jersey.

preparation was diluted with water in proportions equivalent to 2 quarts to 100 gallons of water. Dusts were, (1) Derox,[4] a mixture of powdered derris root and talc, standardised to about .55 per cent rotenone content, (2) Pyrethrum powder[2], of about 1 per cent pyrethrins content, (3) Cubor[3], a talc mixture containing derris and pyrethrum extractives plus 10 per cent powdered derris root. The latter two dusts were further diluted with equal parts of Georgia clay.[5] Sprays were applied with a Deming knapsack machine, and dusts with a Niagara rotary hand gun, going once over the rows.

The infestation was largely due to *Pieris rapae*, although as the season advanced from June to July *Plutella maculipennis* and *Autographa brassicae* became increasingly numerous. The first generation of *rapae* was well defined, appearing with the first warm days in April and terminating about June 15th. This generation caused little injury. Butterflies of the second brood were numerous during the latter half of June, during which time worm infestation was prevalent and noticeable, the period being marked by deficiency in precipitation.

TABLES 1 AND 2. DATA OBTAINED FROM THE USE OF CERTAIN BRANDS OF DERRIS AND PYRETHRUM PRODUCTS FOR THE CONTROL OF CABBAGE WORMS, AS INDICATED BY THE FREEDOM OF THE INNER FOLIAGE FROM INFESTATION FOLLOWING EACH APPLICATION

		Percentage of uninfested plants following each application											
	Dilution	Ser. 1		Ser. 2									
Name of dust	with clay	1st	2nd	1st	2nd	Ave.	1st	2nd	Ave.	1st	2nd	3rd	Ave.
		Cauliflower					Broccoli			Cabbage			
Derox	———	96	100	84	100	95	100	96	98	88	96	96	93.3
Pyrethrum	50–50	100	92	88	92	93	84	80	82	88	92	88	89.3
Cubor	50–50	84	80	100	76	85	96	72	84	84	80	88	84.0
Checks	———	4	16	40	4	16	60	44	52	28	8	0	12.0

			Percentage of uninfested plants following each application				
Crop	Name of insecticide	Dilution*	1st	2nd	1st	2nd	Average
			Plot 1		Plot 2		
Cabbage	Hellthspra No. 1	1–200	88.2	55.0	66.6	22.2	58.0
	Pyrethrum extr. plus penetrol	1–200	100.0	36.8	93.3	23.5	63.4
	Cubor spray	1–200	85.7	44.4	86.6	44.4	65.3
	Checks	———	32.5	21.4	49.9	19.5	30.8
	Derox dust	———	100.0	100.0	100.0	100.0	100.0
	Pyrethrum powder	50–50	100.0	94.7	92.8	75.0	90.6
	Cubor dust	50–50	100.0	78.9	85.7	82.3	86.7
	Checks	———	46.7	27.0	40.0	19.6	33.3

*In case of sprays dilution in water by volume. In case of dusts dilution with clay by weight.

Applications were made on June 27–28, July 6, and July 18, under favorable conditions. Rates of application were equivalent to 60 gallons per acre, increasing to 80 gallons for sprays; for dusts, 25 to 28

[4]Product of Bowker Chemical Co., New York City.

[5]Product of Edgar Bros., Metuchen, New Jersey.

pounds, 30 pounds, and 36 pounds per acre per each successive application in Series I (Table 1), and 22 pounds and 33 pounds per acre per successive application in Series II (Table 2).

Data from such treatments were recorded three to five days after each application, the results being based on the degree of freedom from worm infestation exhibited by the inner foliage. These data are summarised in Tables 1 and 2.

From the above data it will be seen that the various dust mixtures were highly effective in maintaining the inner foliage free from worms. With sprays the results were not so promising. The initial kill after first application of spray appears to have been high, but after the second application, with increasing growth of plants and infestation, the percentage of uninfested plants was markedly reduced.

FIELD TESTS WITH LATE CROP OF CABBAGE.—The experiment was divided into three parts with a view to testing the comparative merits of sprays and dusts, (1) when applied at various intervals during the period of treatment, (2) when applied at various strengths, (3) when applied with various spreaders for sprays and diluents for dusts. Tests in numbers (1) and (2) were carried out in triplicate, in (3) repeated four times. The source of rotenone for the sprays was the commercial rotenone powder of 98 per cent purity. The material was added to the various sprays in the form of an acetone solution. The source of rotenone for dusts was a powdered derris root of 4 per cent rotenone content. The sprays and dusts were applied with machines as in the case of the early crops. Treatment in all plots commenced about two weeks after the plants had been set out in the field and were continued for about seven weeks until early October. The period was marked by excessive precipitation, over 9 inches of rain falling in August and in September. Worms causing most injury to foliage were those of *rapae* and *brassicae*, *maculipennis* being less injurious.

In the series of tests to determine the effect of various lengths of intervals between applications on the effectiveness of the treatment, so-called 7-day-interval applications were made on August 17–18, August 25, September 1, September 7–8, September 18, September 26, and on October 4 for dust only, totalling six applications for spray and seven for dust and averaging intervals of nearly 8 days between applications. So-called 10-day-interval applications were made on August 7–18, August 27–28, September 7–8, September 18, and September 28–29, totalling five applications and averaging intervals of 10½ days. So-called 14-day-interval applications were made on August 17–18, September 1, September 18, and September 30, for spray and October 4 for dust, totalling four applications and averaging intervals for about 15 days.

The spray consisted of a rotenone-penetrol-water emulsion at the rotenone strength of 1 to 10,000, the penetrol being used at 1–200 parts of water. The dust mixture consisted of derris diluted with clay to give .5 per cent rotenone content. The rates of application for sprays were equivalent to 60 gallons per acre and increased to 80 gallons per acre per application; for dusts, 18½ pounds to 37 pounds per acre per application.

Records were taken on October 10 to 12 relative to the comparative effectiveness of the various treatments as indicated by the extent of feeding injury on the foliage and head, whether slight, moderate or severe. The data are summarised in Table 3.

TABLE 3. DATA OBTAINED FROM CABBAGE PLANTS TREATED WITH A ROTENONE-OIL SPRAY OR A DERRIS-CLAY DUST AT VARIOUS INTERVALS FOR CONTROL OF CABBAGE WORMS

Treatments	Intervals between applications	Number of applications	Plant injury		
			None	Slight	Moderate-severe
			Percentage		
Rotenone-penetrol spray, .0001 rotenone strength	7-day	6	39.0	36.3	24.6
	10-day	5	42.7	30.3	27.0
	14-day	4	16.4	32.3	51.3
Checks	———	–	6.0	18.7	75.3
Derris-clay dust 5 per cent rotenone strength	7-day	7	79.8	17.0	3.2
	10-day	5	75.0	16.7	8.3
	14-day	4	76.0	14.9	9.1
Checks	———	–	27.4	35.8	36.8

Owing to the marked differences between check plats in sprayed and dusted sections of the experiment, it seems inadvisable to draw any conclusions regarding the comparative merits of sprays and dusts. However in the sprayed plots there was a marked increase in the amount of feeding injury when the interval between applications was extended to "14-day", whereas with dusts, under the conditions prevailing, a "14-day" interval between applications appeared to have very slight effect on results when compared with those obtained at so-called 10-day interval.

In the series of experiments to determine the rotenone strength of sprays and dusts that might be effective in controlling cabbage worms, sprays were used consisting of penetrol and water, 1–200 parts. To this was added rotenone in strengths equivalent to 1 part of rotenone to 5,000, 10,000 and 15,000 parts of spray mixture. Dusts were prepared of 1, .5, and .33 per cent rotenone strength by the dilution of powdered derris root with Georgia clay.

Applications were made on August 17–18, August 25–26, September 5, September 18, and September 28–29, at rates equivalent to 70 to 80

gallons per acre per application for sprays, and 20 to 40 pounds for dusts, according to the increasing growth of the plant. Data were recorded at the end of the season concerning the comparative effectiveness of the various sprays and dusts as in experiments dealing with the factor of intervals between applications. The records are summarised in Table 4.

TABLE 4. DATA OBTAINED FROM CABBAGE PLANTS TREATED WITH SPRAYS AND DUSTS OF VARIOUS ROTENONE STRENGTHS TO CONTROL CABBAGE WORMS

Treatments	Dilution of rotenone content	Plant injury		
		None	Slight	Moderate-severe
		Percentage		
Rotenone-penetrol spray	1–5000	52.8	30.1	17.1
5 applications	1–10000	54.8	25.3	19.9
	1–15000	37.9	36.1	26.0
Checks	———	7.5	23.9	68.6
Derris-clay dust	1-per cent	80.2	11.5	8.3
5 applications	.5-per cent	80.7	10.3	9.0
	.33-per cent	70.5	21.8	7.7
Checks	———	38.5	32.0	29.5

As in Table 3 plants dusted showed less plant injury than plants sprayed, but the issue is largely obscured owing to the marked differences between the respective series of check plats. In the sprayed plats a rotenone-oil spray of 1–15,000 rotenone spray dilution was apparently not as effective as sprays of 1–10,000 and 1–5,000 spray dilution in reducing feeding injury. In the dusted plats a derris clay mixture of .33 per cent rotenone content was slightly less effective than dusts of .5 and 1 per cent rotenone content.

In tests of various spreaders with rotenone sprays the following materials were used, a 40% potash cocoanut oil neutral soap, Penetrol, a powdered lignin pitch, dried skim milk. These materials were added to water in the proportion by weight of 1 to 200 respectively, the soap being based on actual soap content. Rotenone was added to such sprays at a strength equivalent to 1 to 10,000 parts of spray. In tests of various diluents for derris dusts the following materials were used, talc, Georgia clay, tobacco dust, hydrated lime. These materials were mixed with a powdered derris root of 4 per cent rotenone content in the proportion by weight of 7 parts to one respectively. Dust mixtures for all applications were prepared at the commencement of the experiment. Applications were made on August 17–18, August 25–26, September 5, and September 18, and September 28–29. The rates of application for sprays were equivalent to 60 gallons to 80 gallons per acre per application as plants increased in growth; for talc dusts 20 to 40 pounds, for clay dusts 20 to 35 pounds, for tobacco dusts 30 to 40 pounds, for hydrated lime dusts 25 to 50 pounds. Data were recorded at the end of the season as in other tests, and are summarised in Table 5.

TABLE 5. DATA OBTAINED FROM CABBAGE PLANTS TREATED WITH ROTENONE SPRAYS CONTAINING VARIOUS MATERIALS AS SPREADERS, AND WITH DERRIS DUSTS MIXED WITH VARIOUS DILUENTS TO CONTROL CABBAGE WORMS

Treatments		Plant injury		
		None	Slight	Moderate-severe
Spray mixtures			Percentage	
Rotenone+neutral soap and water (1–10000)		54.2	23.4	22.4
Rotenone+penetrol and water (1–10000)		54.2	29.2	16.6
Rotenone+lignin pitch and water (1–10000)		52.8	28.8	18.4
Rotenone+dry skim milk and water (1–10000)		53.4	30.0	16.6
Checks		8.2	25.1	66.7
Dust mixtures				
Derris+talc	.5% rotenone strength	83.5	13.5	2.9
Derris+clay	.5% rotenone strength	80.5	15.5	4.0
Derris+tobacco dust	.5% rotenone strength	77.7	13.4	8.9
Derris+hydrated lime	.5% rotenone strength	64.5	16.5	18.9
Checks		36.3	37.8	25.9

As in previous tables the data showed a marked difference in degree of plant injury in checks of sprayed and dusted sections of the experiment rendering comparisons of dry and wet treatments of little significance. There was little difference between the results obtained from the use of various spreaders for the rotenone spray, all seemed of equal value. Of the diluents in a derris dust mixture, the results from the use of talc and clay were slightly superior to those from tobacco dust, whilst the results from the use of hydrated lime were inferior to all three.

SUMMARY.—Derris dusts have given satisfactory results in the field for the control of cabbage worms. A derris-clay dust of .5 per cent rotenone content applied four times at about 15-day intervals during a 10-week period of infestation gave as satisfactory results as five or seven applications at shorter intervals.

A derris-clay dust of .5 per cent rotenone strength gave as satisfactory results as dusts of 1 per cent rotenone strength. A dust of .33 per cent rotenone strength was not as effective.

Talc, clay, and tobacco dust, gave promise of being satisfactory diluents for derris dusts. Hydrated lime apparently affected adversely the toxicity of derris dusts.

Rotenone sprays did not give as high degree of control as dusts, possibly due to the apparently greater infestation in the sprayed section as indicated by the untreated plants. A rotenone spray of 1–10,000 dilution was as effective as sprays of 1–5,000 dilution. There was very little difference in the comparative merits of the various spreaders used with rotenone when applied as freshly mixed sprays, equally satisfactory results were obtained from all sprays.

TOXICITY OF VARIOUS EXTRACTS OF DERRIS ROOT TO SUCKING AND CHEWING INSECTS

By JOSEPH M. GINSBURG, Ph.D., *Biochemist in Entomology*, JOHN B. SCHMITT, M. S., and PHILIP GRANETT, B. S., *Graduate Assistants*

ABSTRACT

Derris root was extracted with acetone, alcohol and water, using two different processes. One process consisted of continuous distillation in Soxhlet apparatus for 10 hours. The other process consisted of making a suspension of the ground root in the solvent and allowing it to stand for 48 hours. The mixture was filtered thru cheesecloth and washed several times with fresh solvent. Secondary extracts were obtained by re-extracting the root residues from one solvent with another solvent. The primary and secondary extracts were tested on apple aphis, silk moth caterpillars and mosquito larvae. The results suggest the following conclusions.

Water soluble organic solvents such as acetone and alcohol are able to extract practically all of the water-soluble and water-insoluble ingredients of derris root toxic to sucking insects. Either continuous distillation or soaking with subsequent filtration and washing will extract practically all the active principles when acetone or alcohol is used. Water does not extract all the toxic principles of derris root. At low dilutions the water extracts compared well in toxicity with acetone and alcohol extracts, but proved inferior to them in high dilutions. Water extracts rapidly deteriorate on standing with resultant loss of toxicity. (Paper withdrawn for publication elsewhere.)

SOME FIELD TESTS SHOWING THE COMPARATIVE EFFICIENCY OF DERRIS, PYRETHRUM AND HELLEBORE POWDERS ON DIFFERENT INSECTS[1]

By CLYDE C. HAMILTON, *Associate Entomologist, New Jersey Agricultural Experiment Station, and* LOUIS G. GEMMELL, *Assistant on the Fellowship Work*

There has been a considerable amount of work done with rotenone, pyrethrum and nicotine sprays or dusts against various insects. Much of this work, however, with derris or pyrethrum extracts was done with materials in which the rotenone or pyrethrin content was not known. Very little of it was done with the powder materials so that the three insecticides could be directly compared. The data presented in this paper compare the action of derris powder, pyrethrum powder and hellebore powder, each, insofar as knowledge will permit with a known content of the active principle, against different insects. It was originally planned to include tobacco powder in the tests. However, the

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

much larger size of the tobacco powder particles and the difference in the way the tobacco powder acts upon insects made comparisons difficult.

The data are taken from work done on funds furnished by McCormick and Company, Inc., and Derris Inc., for investigations on the toxicity of these insecticides to insects.

The derris powder tested 4 per cent rotenone, was air floated and was furnished by Derris Inc. The pyrethrum powder was furnished by McCormick and Company, Inc., and contained 1.16 per cent pyrethrins determined by McCormick & Co., according to the copper reduction method of analysis. The hellebore was purchased from S. B. Penick and Company and was stated to contain 0.8 per cent active principle. The derris powder was diluted with inert clay to obtain the desired per cent of rotenone or sometimes mixtures of derris powder, pyrethrum powder and clay were used. Thus, to make a dust containing 0.5 per cent rotenone and 0.5 + pyrethrins, 12½ parts of the 4 per cent derris dust, 50 parts of the pyrethrum powder containing 1.16 per cent pyrethrins, and 37½ parts of inert clay were thoroughly mixed.

Most of the tests, except some of those on plant lice were conducted in the field. The materials were applied either with hand dusters of the bellows type or the fan type or with power dusters. Thorough applications were made in all tests.

TESTS AGAINST PLANT LICE.—Laboratory tests with the spirea aphis (*Aphis spiraecola*) gave the following kill 24 hours after dusting. 1. Derris powder (25% derris powder and 75% clay, giving 1% rotenone) 87.7 per cent; 2. Red A. pyrethrum powder (1.16% pyrethrins) 95.5 per cent; 3. a mixture of derris and pyrethrum powder (12½% derris powder, 50% Red A. pyrethrum powder and 37½% clay, or containing 0.5% rotenone and 0.58% pyrethrins) 98.5 per cent; 4. hellebore (0.8% active) 16.3 per cent; check 7.3 per cent dead.

In a second test the above materials were applied both as dusts and as sprays. The dusts were applied as shown in the preceding paragraph and the same materials when applied as sprays were diluted 1 part to 400 parts of water. The derris dust gave 65.5 per cent kill and when applied as a spray 85.5 per cent kill. The Red A. insect powder gave 73.9 per cent kill applied as a dust and 41.3 per cent kill applied as a spray. The mixture of derris and pyrethrum gave 85.5 per cent kill as a dust and 75.4 per cent kill applied as a spray. Hellebore gave 11.7 per cent kill applied as a dust and 15.0 per cent kill applied as a spray. The check, sprayed with water, had 16.5 per cent dead.

The tests show that derris powder, pyrethrum powder or mixtures of

the two were effective against plant lice while hellebore was not effective. Derris powder appeared to be more effective when applied as a spray while the pyrethrum powder was more effective applied as a dust. Mixtures of the derris and pyrethrum powders were slightly more effective when applied as dusts than when applied as sprays.

In laboratory tests against the cabbage aphis (*Brevicoryne brassicae* Linn.) the Red A. pyrethrum powder gave 94.9 per cent kill, the derris powder (containing 1% rotenone) 22.4 per cent kill, the mixture of the derris powder and pyrethrum powder 73.0 per cent kill and the hellebore 1.7 per cent kill. The check contained 7.1 per cent dead, and insects dusted with inert clay 2.7 per cent dead.

A second test against the cabbage aphis gave quite similar results. In all the tests the plant lice dropped off the plants soon after dusting in all cases where pyrethrum dusts or mixtures of pyrethrum and derris were used. The derris powder did not cause a rapid fall and no dropping occurred where the hellebore powder was used.

Tests in a nursery against the Norway maple aphis (*Periphyllus lyropictus* Kess.) gave approximately 90 per cent kill with the pyrethrum powder and 40 per cent kill with each of two derris dusts, one containing 1 per cent rotenone and the other 0.5 per cent rotenone. Two hellebore dusts, one full strength and the other diluted with an equal part of inert clay, gave no appreciable drop at the time of dusting or control after several days.

Tests Against the Grape Leaf Hopper.—Tests against the grape leaf hopper (*Erythroneura comes* Say) were conducted at the vineyard of Mr. Theron McCampbell near Holmdel. The hand dusted plots consisted of single rows of grapes about 100 feet long. The machine dusted plots consisted of from 4 to 6 rows of grapes about 800 feet long. A bean power duster with a self mixing hopper was mounted on a Dodge chassis. A frame covered with canvas was attached to one side of the Dodge chassis and extended out over the row of grapes. The distributor outlet from the duster and the exhaust from the car entered at the lower front end of the canvas hood. The arrangement gave an excellent distribution of the dust.

On the hand dusted plots the number of nymphs and adults were counted on 100 leaves while on the power dusted plots counts were made from 300 leaves. The data on the machine dusted plots are given on the basis of 100 leaves. The applications were thorough and on the machine dusted plots the dust was applied at the rate of approximately 100 pounds to the acre. The foliage was dense, the leaves large and the infestation was severe. Many adult leaf hoppers were present.

TABLE 1. AVERAGE OF DUST TESTS APPLIED BY HAND AGAINST THE GRAPE LEAF HOPPER, AND PER CENT INFESTATION COMPARED WITH CHECK

Materials	No. of counts	One day counts: Average of total nymphs & adults	One day counts: Per cent infestation	Seven day counts: Average of total nymphs & adults	Seven day counts: Per cent infestation
Checks	9	618.4	100	618.4	100
1. Derris 12½% Clay 87½%	2	134	21.6	48.5	7.8
2. Derris 25% Clay 75%	3	81.3	13.1	25.6	4.1
3. Red A. 30% Derris 20% Clay 50%	3	47.6	7.6	23.3	3.7
4. Red A. insect powder	3	10.3	1.6	25.0	4.0
5. Red A. 50% Clay 50%	2	45.5	7.3	67.0	10.8
6. Red A. 30% Clay 70%	2	91.5	14.7	106.0	17.1
7. Hellebore	3	471.0	76.1	666.0	100

The data in Table No. 1 show a big reduction in leaf hoppers on the plots dusted with derris or pyrethrum, but no reduction on the plot dusted with hellebore. On the pyrethrum plots the control at the one day counts was better than at the 7 day counts indicating some reinfestation and a lack of lasting power of the pyrethrum dust. On the derris dusted plots the control was better at the 7 day counts than at the one day counts. The data also show slightly better control with the stronger concentrations of both the derris and the pyrethrum dusts.

Table No. 2 shows good control with all the mixtures except the first one which contained 10% pyrethrum powder equivalent to 0.073% pyrethrins and 6.5% derris powder equivalent to 0.25% rotenone. In the power dusted plots the control at the 7 day count was better with all materials than at the one day count. This may have been due to the larger blocks treated thus preventing reinfestation by migration.

Most of the vineyard was dusted with a nicotine dust made by adding 1½ pints of "Black Leaf 50" to a 50 pound bag of lime, mixing for several minutes and then applying this dust at the rate of approximately 200 pounds per acre. This nicotine dust knocked down the leaf hoppers but did not kill them and all stages recovered in 1 to 2 hours. To effect a kill the soil was cultivated with a disc type cultivator within one-half hour after dusting covering the leaf hoppers. This gave a final kill equivalent to that obtained in the tests with derris powder or pyrethrum powder or mixtures of the two powders.

TESTS ON THE ELM LEAF BEETLE.—(*Galerucella luteola* Mull.) Small elm trees on the Rutgers College campus infested with larvae and

TABLE 2. NUMBER OF GRAPE LEAF HOPPERS PER 100 LEAVES AND PER CENT REDUCTION AT ONE AND SEVEN DAYS AFTER TREATMENT WITH POWER DUSTER

	Materials			One day counts				Seven day counts			
				Nymphs	Adults	Total	% Infestation	Nymphs	Adults	Total	% Infestation
	Check			352.6	104	456.6	100	352.6	104	456.6	100
1	Red A. Insect Powder	(.73% Pyrethrins)	10%	23.3	59.3	82.6	18.0	0.33	28.6	29.0	6.3
	Derris Powder	(4% Rotenone)	6.5%								
	Clay and Talc		83.5%								
2	Red A.	(.73% Pyrethrins)	20%	3.0	22.3	25.3	5.5	0.0	10.0	10.0	2.1
	Derris Powder	(4% Rotenone)	13%								
	Talc		67%								
3	Black Arrow 5000		30%	5.0	30.6	36.6	7.9	0.3	7.0	7.3	1.5
	Derris Powder	(4% Rotenone)	13%								
	Clay and Talc		57%								
4	Red Arrow	(.73% Pyrethrins)	20%	24.0	4.3	28.3	6.1	1.0	15.0	16.0	3.5
	Talc		80%								
5	Derris Powder	(4% Rotenone)	13%	13.3	4.6	18.0	3.9	0.0	9.3	9.3	2.0
	Talc		87%								
6	Black Arrow 5000		50%	27.6	8.0	35.6	7.7	3.0	13.6	16.6	3.6
	Talc		50%								

adults of the elm leaf beetle were sprayed June 18 with several dust materials diluted 1 pound in 3 gallons of water. Table No. 3 shows the control obtained on the trees at the time of spraying as determined several days later and the control by placing larvae on leaves of twigs collected 3 and 6 days after sprayed. The weather had been clear with no rain between the time of spraying and collecting the twigs for the tests. About 50 larvae were used in each laboratory test on the leaves. Counts were made 48 hours after placing the larvae on the foliage.

TABLE 3. TESTS AGAINST THE ELM LEAF BEETLE WITH DERRIS, PYRETHRUM AND HELLEBORE POWDERS

Material	On trees 1 day after spraying	Per cent kill obtained On twigs 3 days after spraying	On twigs 6 days after spraying
1 Pyrethrum powder (1.16% pyrethrins)	No live larvae found	27.5	10.2
2 Hellebore	Some larvae alive, active and feeding. Fair control	12.5	0.0
3 Derris (4% rotenone) 25% Clay 75%	A few alive, no activity or feeding. Good control	96.1	58.7
4 Pyrethrum powder 50% Derris powder 12½% Clay 37½%	A few larvae alive, not active and no feeding	83.7	40.8
5 Check	All alive, active and feeding	3.4	2.2

The data show that derris powder and pyrethrum powder both gave good control in field tests and that the foliage sprayed with dusts containing derris powder gave considerable kill when collected 3 and 6 days after spraying. Pyrethrum retained some toxicity for 3 and 6 days while hellebore had little toxicity on the third day and had lost all of its toxicity by the sixth day.

TESTS ON INSECTS INFESTING CABBAGE.—Tests on insects infesting cabbage were conducted at two places. In one field near West Freehold a dust consisting of Red A. Insect Powder (1.16% pyrethrins) 30%, derris powder (4% rotenone) 20% and inert clay 50% was applied with a horse drawn traction duster. Six rows were dusted at one time and two applications were made at 7 day intervals. The cabbage was just beginning to head. The field was well infested with one or more cabbage worms per plant. An examination several days after the second dusting showed 4 cabbage worms only on 50 plants. The cabbage flea beetle (*Phyllotreta vittata* Fab.) was abundant and was easily killed. Many cabbage plants showed from 50 to 100 dead flea beetles at the base of the outer cabbage leaves. Many dead cabbage aphis were found although the control was not satisfactory. Thrips infesting the under surface of the outer leaves were apparently not reduced in numbers.

A second field of cabbage at Milhurst near Freehold was divided into

blocks 22 rows wide and 25 plants in a row, making about 550 plants to the test block. These plants were under overhead irrigation, were growing rapidly and were just beginning to form heads at the time of the first dusting. They were dusted with a Vermorel bellows hand duster applying the dust to the center of the forming heads. Applications were made on July 13 and 21 and counts made on July 20 and 28. The total number of larvae and pupae on 50 plants in each plot was noted. The data are given in Table No. 4.

TABLE 4. TESTS ON CABBAGE WORMS AT MILHURST, N. J.

Material	Larvae and pupae per 50 plants				
	First count		Second count		Per cent infestation of treated plots counting check as 100%
	Larvae	Pupae	Larvae	Pupae	
Check	40	0	22	7	100
1 Hellebore	7	0	5	1	18.8
2 Derris powder 12½% / Clay 87½%	0	1	3	1	7.2
3 Derris powder 25% / Clay 75%	0	1	4	0	7.2
4 Red A. insect powder	3	1	18	4	37.6
5 Red A. insect powder 30% / Derris 20% / Clay 50%	0	1	3	0	5.7
6 Red A. insect powder 50% / Clay 50%	0	0	19	6	36.2

The tests on the cabbage plants show that dusts containing derris powder gave better control of cabbage worms than those dusts consisting of hellebore or of pyrethrum powder. In these tests hellebore gave better control than did pyrethrum powder.

SUMMARY.—The tests with powders containing derris, pyrethrum or hellebore show the following.

In the laboratory on certain plant lice such as spirea aphis and cabbage aphis and in field tests on Norway maple aphis, when applied as dusts, pyrethrum powder gave a quick and good kill, derris powder a fair kill and hellebore very little kill. When these dusts were diluted in water, the derris powder gave the best kill, pyrethrum powder gave a satisfactory kill, but not as good as the derris powder and hellebore again gave an unsatisfactory kill.

On the grape leaf hopper derris powder and pyrethrum powder or mixtures of the two powders gave satisfactory control. Applications with the power duster show that dusts containing derris powder equivalent to 0.5% rotenone was as effective as those dusts containing 1.0% rotenone. Also that a pyrethrum powder (containing 0.73% pyrethrins) used 1 part to 4 parts of clay gave good control of the leaf hoppers. There were some indications that the pyrethrum powder acted quicker

on the grape leaf hopper than did the derris powder but that the derris powder retained its toxicity for a longer time. Hellebore was ineffective against the grape leaf hopper. Heavy applications of a dust containing 1½% nicotine knocked down the grape leaf hoppers but did not kill them. Cultivation with a disc cultivator before the leaf hoppers recovered gave a satisfactory kill with the nicotine dust.

Tests on the elm leaf beetle gave good control with derris powder, pyrethrum powder or mixtures of these two, when applied at the rate of 1 pound in 3 gallons of water. The derris treated trees retained considerable toxicity for 6 days, the pyrethrum treated trees some toxicity and the hellebore treated trees had lost most of their toxicity at the end of 3 days.

Tests on the cabbage worm showed the possibility of good control with derris, pyrethrum or hellebore dust. The derris dusts were the best, hellebore next best and pyrethrum the poorest.

The tests further show that diluting the derris powder or pyrethrum powder or mixture of the two in water and applying as sprays gave good control against plant lice and elm leaf beetles.

TENTATIVE STANDARD CONCENTRATION OF TAR DISTILLATES FOR CERTAIN INSECTS[1]

By F. Z. HARTZELL and G. W. PEARCE, *New York State Agricultural Experiment Station, Geneva, N. Y.*

Domestic brands of tar distillate emulsions, during the past few years have, for the most part, contained about 80 per cent of so-called active ingredients and about 20 per cent of water and emulsifying agents. Of the "active ingredients," from 2 to 9 per cent were tar acids, from 55 to 60 per cent consisted of coal tar creosote oil, while the petroleum oil content varied from 15 to 20 per cent in most of the different brands. The variations mentioned were due to the fact that each compounder generally used a different formula. It should be stated that each manufacturer appeared to maintain a uniform product in his particular brand. This is the type of emulsion that was considered in making the suggestions for dilutions given in Bulletins Nos. 636 and 637 of The Geneva Station. After these were in press a new situation developed due to modifications in formulas by some manufacturers of well known brands and the appearance of new brands which differ widely from the composition mentioned above. At the present time two tendencies seem to be evident. First, with the control of San Jose scale and rosy aphid in

[1]Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 22.

mind, certain firms that make well known brands are inclined to add more petroleum oil, which necessitates a reduction in the amount of creosote oil in their mixtures. Usually the same brand name has been retained with no statement on the label regarding the amount of each ingredient present, thus giving no indication that the formula has been changed. Second, some of the new brands have a high creosote oil content with little or no petroleum oil present, while others differ in composition from that found in brands used in our field tests up to this time. This situation complicates the issuing of general directions for the use of these materials. In the case of brands whose composition has been changed, past experience with such a brand offers no indication of the future performance of the modified mixture. Owing to wide differences in composition, general recommendations covering all brands cannot be given unless based on the amount of creosote and petroleum oil content. As will be shown later, probably all brands containing less than 60 per cent tar oil would not be suitable to use in orchards where severe infestations of bud moth are present.

For the sake of economy as regards the fruitgrower, for the assistance of men directing spray service, and also for the best interests of manufacturers, it seems advisable that tentative standards be established as regards concentrations of creosote oil in the spray mixtures for the several pests involved, and that compounders state on the label the percentage of each kind of oil and of the tar acid in the stock emulsions.

Action of Ingredients.—Much remains to be determined regarding the action of the various ingredients of tar distillate emulsions on different insects. However, the data from field and laboratory tests, supplemented by chemical analyses, indicate that tar acids reduce the toxicity of the emulsions. Another fact that seems to be indicated by the data is that aphid eggs, bud moth, oystershell scale, and scurfy scale are vulnerable to creosote oil while San Jose scale and the eggs of the red banded leafroller are killed by petroleum oil. Apparently there is a limit to the extent that one oil can be substituted for the other in an emulsion without affecting the toxicity of the material towards certain pests. The creosote oil apparently should have a distillation range between 200° and 355° C with not more than 15 per cent of the oil boiling between 200° and 230° C. The acid content should not exceed 5 per cent. This will be designated straight run creosote oil.

Concentrations for Certain Insects.—An analysis of the data from tests in commercial orchards indicate that the following concentrations of straight run creosote oil will give efficiencies of from 95 to 100 per cent; black cherry aphid and green apple aphid 1.6 to 1.8 per

cent; rosy aphid 1.8 to 2.4; oystershell scale 3.0 to 4.5; scurfy scale 3.6 to 4.5 per cent. The data also indicate that from 55 to 70 per cent of the hibernating caterpillars of the eye-spotted bud moth are destroyed at a creosote oil concentration of 3 per cent, but in order to secure an efficiency of from 70 to 85 per cent there is required at least 4.5 per cent of creosote oil. Previous experiments by other workers at the Geneva Station indicate that efficiencies of from 97 to 100 per cent are generally secured against San Jose scale with 2.5 per cent of lubricating oil (viscosity 100 seconds at 100° F. Saybolt) when the infestation is moderate, and with 3.0 per cent when the infestation is severe; also that 6 per cent of the same type of lubricating oil is required to secure an efficiency of from 95 to 100 per cent against the eggs of the leafroller. Furthermore, the experiments during the past three seasons indicate that, generally speaking, under New York conditions, a concentration of 6 per cent of oil, either petroleum oil alone, creosote oil alone, or a mixture of both, is about the maximum that is safe for apple trees. For this reason the danger point is tentatively set at 6.2 per cent of total oil.

Owing to the wide range in amount of each kind of oil that will be found in the different brands if the contemplated formulae are used, it is suggested, first, that all concentrations for diluted spray mixtures be stated in terms of creosote oil and petroleum oil; and second, that the label on each container state the percentage of tar acid, of coal tar creosote oil, and of petroleum oil in the emulsion. With this information the fruitgrower can easily determine the amount of emulsion to use for any susceptible pest by means of the formulae given below.

In an effort to control aphids and San Jose scale with a single application, the tendency has been to increase the petroleum oil content of the emulsions which necessitates a corresponding reduction in the amount of creosote oil present. As regards New York apple orchards, San Jose scale is not nearly as important as bud moth. In order that tar distillate emulsions may be effective for the control of aphids, bud moth, and San Jose scale with a single application, two alternatives are open for the manufacturers. (1) Either to make a tar oil emulsion with a high creosote oil content and also an emulsion of petroleum oil which will be compatible with and can be added to the former, stating the percentage composition of each, especially as regards the kinds of oils used, thus allowing the growers to add the desired amount of petroleum oil; or (2) to make two distinct emulsions, one having a high creosote oil content to be used for aphids and bud moth, the other having the proportion of creosote oil to petroleum oil in the ratio of 2.4 to 3 to be used for aphids and San Jose scale. Each alternative has certain advantages and

certain disadvantages, altho the first would permit greater flexibility in varying the dosages.

AIDS FOR DETERMINING CORRECT DILUTIONS OF EMULSIONS.—In order to determine the amount of either petroleum or tar distillate emulsion necessary to make a mixture containing a specific amount of either oil, the following equation may be used:

$$g = \frac{100\ c}{d} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (1).$$

To find the number of gallons of petroleum emulsion that should be added to a tar distillate spray when San Jose scale also must be controlled the equation

$$e = \frac{100\ b - gp}{a} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (2).$$

may be employed. In these two equations g = the gallons of emulsion required for each 100 gallons of spray mixture, c = percentage of oil desired in the diluted spray, d = percentage of oil in the concentrated emulsion, e = gallons of petroleum oil emulsion needed, b = percentage of petroleum oil desired in the diluted spray mixture, p = percentage of petroleum oil in the tar distillate emulsion, and a = percentage of oil in the petroleum oil emulsion. An example will clarify the problem. Suppose a grower has a tar wash which contains 65 per cent of creosote oil and 15 per cent of petroleum oil; also that he has a compatible petroleum oil emulsion containing 83 per cent of oil. Suppose further that his orchard has a light infestation of bud moth, a severe infestation of San Jose scale, considerable oystershell scale and rosy aphid, all of which he desires to control. He should use 3 gallons of creosote oil and 3 gallons of petroleum oil in each 100 gallons of the diluted mixture. To find the number of gallons of tar wash required he would substitute in Equation 1 the values for creosote oil given above. Thus

$$g = \frac{100 \times 3}{65} = 4.6$$

Therefore 4.6 gallons of tar distillate emulsion would be required. To find the number of gallons of petroleum oil emulsion to be added, he would substitute the proper values in Equation 2. Thus

$$e = \frac{(100 \times 3) - (4.6 \times 15)}{83} = \frac{300 - 69}{83} = 2.8$$

Therefore, 2.8 gallons of petroleum oil emulsion would be needed.

To show graphically the amount of each kind of oil found in the spray mixture where concentrations from 2 to 10 per cent of the various tar

washes are involved, as well as to depict the wide variation in dilution necessary to combat certain pests when the tar washes contain different

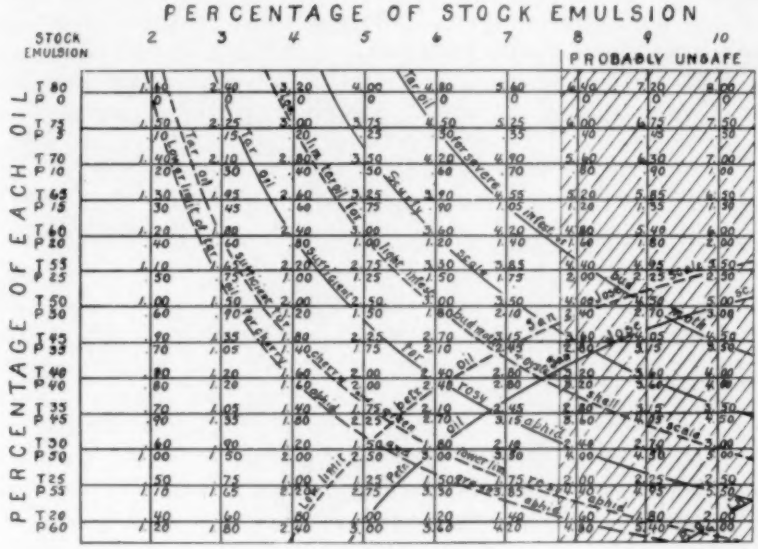


FIG. 29.—Graphic Representation of Amount of Oil in Spray Mixtures at Different Dilutions of Stock Emulsions; also Tentative Concentrations for Certain Insects and Dilutions Necessary.

T = creosote oil, P = lubricating oil, P. O. L. R. = lubricating oil for leafroller. Shaded area represents concentrations that are believed to be unsafe for apple trees.

amounts of each kind of oil, Figure 29 is presented. This chart as well as Figure 30, given later, is based on the supposition that the total amount of both oils constitutes 80 per cent of the emulsion. It is to be noted that in a number of brands it is claimed that the tar distillate and petroleum oil constitute 83 per cent of the emulsion. Since the tar acids constitute several per cent of the emulsion, it will be sufficiently accurate to consider such mixtures as having a total oil content of 80 per cent unless the tar acids exceed 5 per cent.

Figure 30 shows graphically the percentage of petroleum oil to be added to the various dilutions of different tar washes on the assumption that 3 per cent of lubricating oil (not the emulsion) is needed for the control of San Jose scale. To reduce this quantity of oil to the amount of emulsion required, Equation 1 can be used by substituting the proper values for petroleum oil.

It will be noted from these charts that with tar distillate emulsions containing a total oil content of 80 per cent, (1) the maximum reasonably safe concentration of the emulsion is perhaps 7½ gallons per 100 gallons

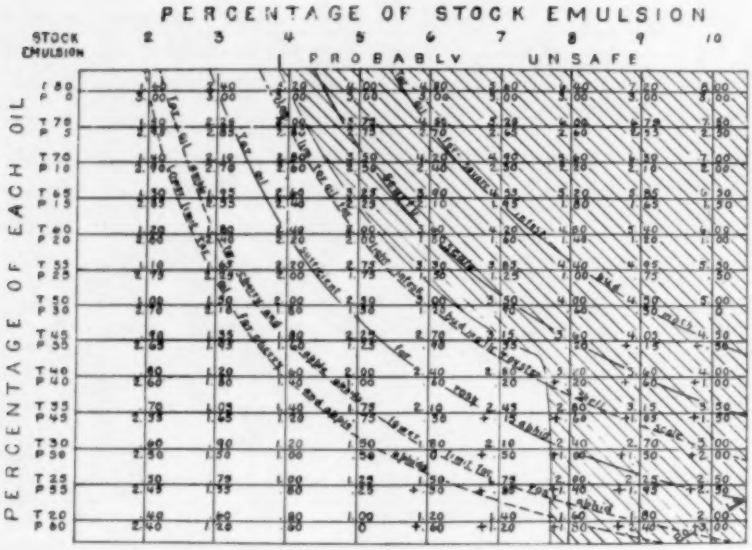


FIG. 30.—Graphic Representation of Amount of Lubricating Oil to Add to Different Dilutions of Various Stock Emulsions for San Jose Scale Control in Addition to the Pests Mentioned.

Symbols and shading have same meaning as in Fig. 29.

of spray mixture. (2) It may be possible to control a severe infestation of San Jose scale in combination with any of the insects shown except possibly scurfy scale and severe infestation of bud moth without exceeding the tentative safety limits for trees. (3) Light infestations of San Jose scale, together with the other insects mentioned, with the exception of severe bud moth, may possibly be controlled by a single application with comparatively little danger to the trees. (4) Altho San Jose scale and leafroller can generally be controlled by a single application of lubricating oil emulsion containing 6 per cent of oil, it is obvious that creosote oil cannot be added to the petroleum oil in sufficient amount to control any of the other pests without risk of tree injury. However, experiments indicate that 6 per cent lubricating oil is often effective in destroying aphid eggs but is not very effective against the bud moth, and only moderately effective against scurfy scale.

The question of compatibility of tar distillate emulsions and petroleum oil emulsions raises a new problem. If such emulsions are not compatible their mixture may cause injury to the buds and twigs. Experiments seem to show that when the two emulsions contain the same kind of emulsifier and the same kind of petroleum oil, the resulting mixture is reasonably safe. Until more is known regarding this problem it seems advisable to use only such emulsions as are recommended by the manufacturers for making mixtures.

NOTES ON SUMMER OIL EMULSIONS[1]

By S. W. FROST, *The Pennsylvania State College*

Spray tests were conducted on apple and peach trees ranging from four to sixteen years old to determine the limits of safety for summer oil emulsions and to determine, if possible, the insecticidal value of these emulsions. The applications on the four and six year old trees were made with a hand sprayer with 150 pounds pressure. The trees were thoroughly drenched in each case. The applications on the 16 year old elberta block were made with a standard spray machine developing 350 pounds pressure. The spraying in this case was done with a spray gun from the ground. The numbers of the trees correspond with those used in 1932[2] and show the results of accumulated applications of summer oil emulsions for several consecutive years. Trees Nos. 16, 20, 22, 24, 26 and 34 received summer oil emulsions in 1931. All trees except Nos. 40 to 60 received four applications of summer oil emulsions in 1932 with various combinations of sulphur or bordeaux. Many of the trees have therefore received two per cent summer oil emulsions for three consecutive years. None show deleterious effects. In a few cases temporary leaf injury was noted when certain incompatible combinations were used but no permanent injury resulted.

Five and ten per cent pine tar soap was used at the rate of ½ pound to 100 gallons of water. These were applied to apple and peach. No injury resulted but at the same time no insecticidal value was evident. The addition of arsenate of lead to ten per cent pine tar soap applied in June resulted in serious injury to apple. The experiment was not repeated. The same combination applied to peach in June and August caused no injury.

[1]Publication authorized by the Director of The Pennsylvania Agricultural Experiment Station November 16, 1933, as technical Paper No. 616.

[2]Jl. Econ. Ent. 26: 334–344. 1933.

Two per cent summer oil emulsion was applied to tree No. 34 for three consecutive years. Arsenate of lead was added to the oil in 1933. No injury resulted and the tree appeared to be in perfect condition on October 1, 1933.

A mixture of 10 pounds of wettable sulphur, 2 gallons of summer oil emulsion, 3 pounds of basic arsenate of lead and 100 gallons of water was applied to four, 4 year old elbertas. The same combination was also applied to twenty, 16 year old elberta trees. No injury resulted in either case. The trees seemed to be invigorated, the foliage was darker green and remained on the trees after the leaves had fallen from adjacent trees.

APPLICATIONS TO FOUR YEAR OLD ELBERTA

Trees* Number	Materials	Amount added to 100 gals. of water	Injury resulting from applications made on June 2	Aug. 2
5	5% pine tar soap..	½ lb.	none	none
9	10% pine tar soap.	½ lb.	none	none
20	10% pine tar soap.	½ lb.	25 per cent de-	
	Arsenate of lead...	3 lbs.	foliation	——
22–25	Meedol.....	2 gals.		
	Koloform.....	10 lbs.	none	none
14–16	Meedol.....	2 gals.		
	Koloform.....	10 lbs.		
	Arsenate of lead...	3 lbs.	none	none
24–26	Ortho K.....	2 gals.		
	Koloform.....	10 lbs.	none	none
4–8–12	Ortho K.....	2 gals.		
	Koloform.....	10 lbs.		
	Arsenate of lead...	3 lbs.	none	none

*Trees Nos. 16, 20, 22, 24, and 26 received 2 per cent summer oil emulsion in 1931. All trees received four applications of 2 per cent summer oil emulsion in 1932.

APPLICATIONS TO SIXTEEN YEAR OLD ELBERTA

Trees number	Materials	Amount added to 100 gals. of water	Injury resulting from applications made on June 2	Aug. 10
40–60	Meedol	2 gals.		
	Koloform.....	10 lbs.	none	none
	Basic A. lead.....	3 lbs.		

APPLICATIONS TO SIX YEAR OLD YORK IMPERIAL

Trees* number	Materials	Amount added to 100 gals. water	Injury resulting from applications made on June 2	Aug. 2
27–29	5% pine tar soap	½ lb.	none	none
30	10% pine tar soap	½ lb.	none	none
32	10% pine tar soap	½ lb.		
	Arsenate of lead...	3 lbs.	none	none
34	Ortho K.....	2 gals		
	Arsenate of lead...	3 lbs.	none	none

*Tree No. 34 received four applications of 2 per cent oil-emulsion in 1931 and in 1932. The other trees received four applications of 2 per cent oil-emulsion in 1932.

The shortage of the peach crop and losses due to severe storms prevented a careful check on the value of the sulphur-oil-lead spray applied to the 16 year old elberta orchard. On August 25 nearly the whole crop fell to the ground and brown rot was plentiful. Since the oriental fruit moth constitutes the chief means of entrance of this disease, the following table gives some idea of the results of the two applications.

RESULTS OF APPLICATIONS TO SIXTEEN YEAR OLD ELBERTA

Treatment	Number of trees	Total number fruit	Number fruit infested by brown rot	Percentage infested by brown rot
2% oil-emulsion with Koloform and Basic lead	21	484	59	12.1
Self boiled lime sulphur	21	399	49	12.0

The present investigations as well as those conducted during 1932 indicate that two per cent summer oil emulsions can be used safely on apple but not in combination with fungicides. If used with lime sulphur or wettable sulphurs, serious burning results especially when applied during the late summer. The finer the sulphur the more serious is the burning. When used in combination with Bordeaux, a residue is left which cannot be removed. It even produces a permanent discoloration of the fruit.

Certain commercial summer oil emulsions can be used safely at two per cent dilution on peach. Wettable sulphurs and basic arsenate of lead may also be added to summer oil emulsions without causing injury. The value of this combination for oriental fruit moth is, however, negligible unless applications are made at weekly intervals.

THE KNOWN DISTRIBUTION OF THE JAPANESE BEETLE IN 1932 AND 1933

By HENRY FOX, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

In former papers[1] the writer has directed attention to the fact that the apparent range of the Japanese beetle (*Popillia japonica* Newm.) in this country actually consists of two quite distinct subdivisions, in one of

[1]Fox, Henry. 1927. The present range of the Japanese beetle, *Popillia japonica* Newm., in America and some factors influencing its spread. Jour. Econ. Ent. 20: 383–391.

———. 1932. The distribution of the Japanese beetle in 1930 and 1931, with special reference to the area of continuous infestation. Jour. Econ. Ent. 25: 396–407.

which the insect occurs at practically all points where suitable environmental conditions prevail, while in the other it is represented only in the form of more or less widely separated local groups or colonies. The former termed the normal range or area of continuous infestation, obviously corresponds to the area that the beetle has come to occupy largely as a direct result of its natural spread year after year from the original point of introduction near Riverton, N. J. The other, and very much more extensive, subdivision, termed the area of discontinuous or of localized infestation, has received the various beetle infestations found within its limits primarily as a result of the conveyance of beetles from the already infested area to previously uninfested localities through artificial means of transportation, with the consequent establishment of more or less flourishing colonies isolated from one another and from the main body of the population.

THE ENTIRE DISTRIBUTION[2] of the Japanese beetle in this country, as recorded up to and including 1933, is shown in Figure 31. The portion shown on the map in solid black corresponds to the area of continuous infestation of that year, while the very much larger portion in which are distributed the circles and dots[3] indicates the area of discontinuous infestation. The map serves to bring out clearly the relatively insignificant size of the area that the Japanese beetle has come to occupy through its own powers of dispersal, as compared with that throughout which it has been scattered by the aid of man. The former, it will be observed, is largely confined to portions of New Jersey, Pennsylvania, and Delaware, with only minor protrusions into adjoining sections of Maryland and New York. The area of discontinuous infestation, on the other hand, has been extended as far north as west-central Maine (Waterville) and northern New York (Watertown), west to southeastern Michigan (Detroit) and central Ohio (Columbus),

[2]The writer is indebted for information on the state of infestation in the area of discontinuous infestation to the unpublished reports of L. H. Worthley, in charge of Japanese beetle quarantine operations, and his associates of the Bureau of Plant Quarantine.

[3]The circles represent localities in which beetles were found in earlier years, but not reported in 1933, while the solid dots are those from which definite records were available in the latter year. The absence of a record is not to be taken as an index that an earlier reported infestation had died out, as the practice of the Bureau of Plant Quarantine, which has had charge of investigating the beetle occurrences in the area of discontinuous infestation, has been to limit its work to those portions in which only the newer infestations have been reported. For many of the older infestations no data on their status in 1933 were available at the time this paper was written, but there can be no question that some, if not all, of them still harbor beetles.

and south to southern West Virginia (Princeton), western North Carolina (Asheville), and to Florence and Greenville, South Carolina. A still more southern limit was reached in the latter State at Charleston, where four beetles were taken in 1931, but where none has since been taken, despite the fact that efforts to trap them there have been made every year since.

KNOWN DISTRIBUTION OF JAPANESE BEETLE IN 1933.
Area of continuous infestation.
Infestations in area of discontinuous infestation recorded in 1933.
Infestations in area of discontinuous infestation recorded previous to 1933.

FIG. 31.—Distribution of the Japanese beetle in the United States up to and including the year 1933. Circles represent localities in which beetles were found in earlier years, but not reported in 1933, while the solid dots are those from which definite records were available in the latter year.

Among the numerous local infestations that are distributed through the area of discontinuous infestation a moderate number have already become sufficiently important to serve as secondary centers of natural dispersal for the beetle. Practically all of these are infestations of long standing, in which enough time has elapsed since the initial infestation to enable the insect to increase to a point at which invasion of the surrounding districts will soon become, if it is not already, evident. Cases

of this kind have been repeatedly found near or just outside the limits of the present area of continuous infestation, where it has become in-

FIG. 32.—Distribution and regional concentration of the Japanese beetle in 1932 in New Jersey and parts of adjoining States. The stippled portion of the map shows the area of continuous infestation, the density of the dots within this area being indicative of the intensity of the infestation. The larger dots interspersed throughout the remainder of the map show the known occurrence of the insect in the part of the area of discontinuous infestation falling within the map limits.

creasingly difficult to discriminate between them and the invasion of the same section by the vanguard of the general beetle population of the continuously infested area. A notable instance of the kind occurred in 1932 in Cape May County, N. J. Although at the end of 1931 the area continuously infested in the county had barely reached farther south than the base of the peninsular portion, in 1932 beetles, although for the most part still extremely scarce, appeared to have become distributed throughout the entire county. Light was thrown upon this perplexing situation that year by the discovery of three flourishing local colonies in the county, one at Cape May Court House, another at Butleigh, and a third in Cape May City. The infestation at Burleigh was on a golf course and was found to have assumed alarming proportions, the beetles being sufficiently abundant to cause quite extensive foliage damage to vines, small trees, and shrubbery about the course and to necessitate poisoning of the greens. Within a mile or two of this place beetles were still very scarce and this was also true of all sections of the county farther north and, therefore, much nearer the original general infestation. Evidently, what was happening in this instance was a simultaneous invasion of the northern part of the peninsula by the vanguard of the main body of beetles, and an early stage in the occupation of the remainder by individuals straying away from such local colonies as those at Burleigh, at Cape May Court House, and at Cape May City.

In other sections similar instances of originally isolated infestations uniting with and apparently accelerating the advance of the general area of infestation have come to light. Indications of these are to be seen in the somewhat sinuous outline of the periphery of the area as portrayed on the map (Figs. 32 and 33), although it must also be admitted that the more rapid advance in some directions than in others may have been due in part to the topography. However, the type of topography recognized as favorable to Japanese beetle invasion is also the type that has determined the course taken by railroads and main motor highways. For this reason it has not been possible to determine just how much of the more rapid extension of the continuously infested area in these directions has been conditioned by topographic features or what part has been played by the dispersal from local colonies established about railway stations or other points where cargoes are unloaded.

Besides the infestations just referred to, which lie close to or just outside the present limits of the area of continuous infestation, certain others located far beyond those limits have reached a point at which they can scarcely fail to serve as independent sources of dispersal.

Examples of such flourishing infestations are those reported from Springfield, Mass.; Bridgeport, Conn.; Baltimore and Cambridge, Md.; Washington, D. C.; and Alexandria, Va. These places are so far removed from the main infestation that dispersal of beetles from them should serve to infest a very considerable amount of surrounding country before the present area of continuous infestation has had time to reach them.

THE AREA OF CONTINUOUS INFESTATION IN 1932.—The area of continuous infestation of 1932 is shown in Figure 32 as the stippled portion of the map, the large black dots outside this area representing the localities at which, in that year, beetles were recorded in the adjoining portion of the area of discontinuous infestation.

In 1932 all New Jersey except its northern quarter was included in the area of continuous infestation, its limits in that quarter being indicated by such places as Phillipsburg in Warren County, Califon in Hunterdon County, Bernardsville in Somerset County, Morristown in Morris County, and Elizabeth in Union County. In the northeast the area was advanced into the southwestern part of Staten Island, New York, where the spread was traced as far as Richmond and Grant City. In Pennsylvania it extended clear across the counties of Bucks, Montgomery, Delaware, and much of Chester into lower Northampton (Easton) and Lehigh (Coopersburg) Counties, the eastern edge of Berks (Boyertown, Douglassville) and the western section of Chester County (Atglen, West Grove). Southwards, in Delaware, the area was restricted in 1932 to the northern half of New Castle County, its limits in the state being marked approximately by such places as Newark, Christiana, St. Georges, and Port Penn.

THE AREA OF CONTINUOUS INFESTATION IN 1933.—The area of continuous infestation of 1933 is shown in Figure 33 as the stippled portion of the map. Owing probably to the general reduction of the beetle population of that year, many parts of the area showed only a slight advance beyond the limits reached in 1932. This was particularly true toward the north where, according to the available scouting records, scarcely any advance was made. Thus, in New Jersey, no clear indications were found of the extension of the range north of such points as Phillipsburg and Port Murray in Warren County, Long Valley and Morristown in Morris County, and Newark in Essex County. At least two of these localities coincide with the limits reached in 1932, while the others lie only a short distance farther north. Possibly some, or perhaps a very considerable part, of this retardation in the northward advance was due to unfavorable topography, the range in 1932 having

advanced clear across the Piedmont Region to the southern limits of the belt of more elevated and rugged country known in New Jersey

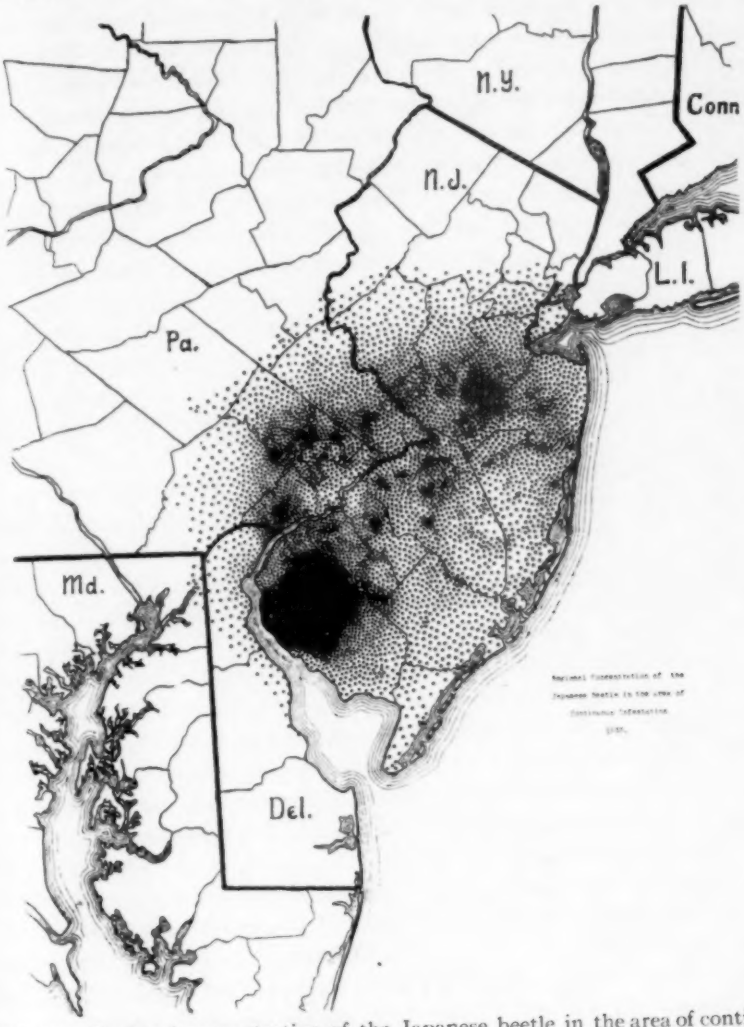


FIG. 33.—Regional concentration of the Japanese beetle in the area of continuous infestation of 1933. Explanation as in Figure 32, but occurrences in area of discontinuous infestation not shown.

as the Highlands. Some support for this view is to be found in the fact that Long Valley, the most northern point in the State to which the range was traced in 1933, is situated in a long narrow valley extending

from the upper borders of the Piedmont country at High Bridge far north into the heart of the Highlands, whereas no beetles were found in the more elevated sections on either side of the valley.[4]

Toward the east in New Jersey, the northward advance in 1933 in the belt of low country lying east of the Watchung Mountains appears to have been more marked than farther west, although in this district much confusion in tracing the expansion of the area of continuous infestation arises from originally isolated infestations long existent in the numerous cites and residential suburbs occupying this district. Farther east the whole of Staten Island became included in the area of continuous infestation. Also on Long Island beetles, evidently carried out to sea from the heavy infestations in Monmouth County, N. J., were reported as washed up in hordes on the beaches of the southern coast, some being found as far east as Fire Island. Of these, certain of those found toward the west end of the island were still alive, a fact which points to an initial inclusion of at least the southwest extremity of Long Island within the area continuously infested.

In Pennsylvania, as in New Jersey, there was only a slight advance in 1933 of the northern limits of the area of continuous infestation beyond those reached in 1932, the limits of spread in this direction being indicated by Easton and South Bethlehem, Northampton County. Westward, in the same State, the area was traced to Zionsville in Lehigh County, Hereford, Earlville, and Gibraltar in Berks County, Christiana in Lancaster County, and New London in Chester County. Farther south, the area of continuous infestation for the first time penetrated into Maryland, extending across the northeast corner of the State to Elkton and Chesapeake City, Cecil County. A marked concentration of beetles was observed in the vicinity of the former, indicative of the junction of the general area with a local area of dispersal from a colony long known as existent in that place.

Probably the most striking expansion of the area of continuous infestation in 1933 was that which took place in Delaware, where its limits were reached as far west and south as Middletown, New Castle County and Smyrna, Kent County, and, in the vicinity of Delaware Bay, as far south as the latitude of Dover. This rather sudden expansion of the area in Delaware was due to its proximity to the main area of unusually heavy infestation in southwestern New Jersey which in 1933 (Fig. 33)

[4]A branch of the Central Railroad of New Jersey traverses this valley and possibly traffic on it may have been responsible for the introduction of the beetle, but this does not seem likely in view of the fact that no signs were found of any tendency toward concentration in the vicinity of the stations along the line.

was extended south in that State to Delaware Bay. Early in July R. J. Sim reported finding numerous beetles washed up on the beaches on the south side of the Bay, a fair proportion of which proved to be alive. This occurred a few days after a period of northeast winds. Doubtless during this period large numbers of Japanese beetles from the heavy infestations in southwestern New Jersey were carried out into Delaware Bay, where they drifted about until cast up on the opposite shores of Delaware. In this way very considerable swarms of the beetle found their way into Delaware from New Castle south to Woodland Beach, below which point they decreased, although small numbers were found alive as far south as Pickering Beach opposite the city of Dover.

The size of the area of continuous infestation, as estimated for each of the two years under consideration, is shown in Table 1, along with its distribution in the different states involved.

TABLE 1. ESTIMATED SIZE OF THE AREA OF CONTINUOUS INFESTATION OF THE JAPANESE BEETLE IN 1932 AND 1933

State	1932 Square miles	1933 Square miles
New Jersey	5,760	6,000
Pennsylvania	2,000	2,120
Delaware	210	560
New York	30	70
Maryland	0	50
Total	8,000	8,800

INTENSITY OF THE INFESTATION IN THE AREA OF CONTINUOUS INFESTATION.—Variations in the intensity of the infestation in the area of continuous infestation are indicated on the maps (Figs. 32 and 33) by the density of the stippling. As was stated in the writer's earlier paper (1932) the infestation is sufficiently heavy to be marked by obvious damage to vegetation throughout west-central and southwestern New Jersey, southeastern Pennsylvania and the northeastern corner of Delaware. This is an area of thickly inhabited and highly cultivated open farming country and residential districts which offer ideal conditions for the establishment and increase of the Japanese beetle. In eastern New Jersey, however, different conditions prevail; the area is relatively sparsely settled, the soils are largely sands and relatively unproductive, and the country is covered with extensive forests of scrub oak and pine, forming the section known as the Pine Barrens. While not rare, Japanese beetles in this section have always been relatively infrequent compared with their abundance in the farming districts nearer the Delaware River. The only outstanding exceptions to this rule have been the more or less limited tracts of originally Pine Barren

country which, through long settlement and intensive cultivation, have been radically changed. In such tracts infestations are often developed that are fully as heavy as those typical of the more generally favorable sections in the western half of the State.

In 1932 the area in which the infestation was accompanied by obvious injury[5] extended north in New Jersey to lower Hunterdon County (Flemington), central Middlesex County (New Brunswick), and north-central Monmouth County (Holmdel); east, rather irregularly through the Pine Barrens, to east-central Monmouth County (Farmingdale), eastern Ocean County (Toms River, Brookville) and southeastern Burlington County (New Gretna); and south to west-central Atlantic County (Elwood, Mizpah) and central Cumberland County (Millville, Greenwich). In Pennsylvania a similar state of affairs was traceable north to north-central Bucks County (Perkasie), and west to west-central Montgomery County (Royersford), and eastern Chester County (West Chester). Southward, in Delaware, the same condition prevailed as far as Wilmington and New Castle.

The most impressive feature of the infestation in 1933 (Fig. 33) was the great reduction of the beetle population in the older infested sections compared with the number present in 1932. This reduction appears to be attributable to the deficient rainfall of the preceding summer which chanced to fall at a time when oviposition and hatching are normally at a maximum. This was followed by a much reduced larval population, reflected in the reduced size of the adult population that emerged in the summer of 1933. There were some local exceptions to this rule, occasional localities showing in the latter year an apparently somewhat heavier infestation than in 1932, but such cases were very few, and, with their exception, all sections of the range heavily infested in 1932 showed a marked reduction in 1933. Some idea of the extent of this reduction can be obtained when it is mentioned that certain tracts in Pennsylvania, which in the spring of 1932 gave an average of 30 Japanese beetle larvae to the square foot, in 1933 yielded an average of only 7 larvae. As a result of this decrease, damage to vegetation in 1933, while obvious throughout all the area similarly infested the year before, was rarely as general or as severe as in 1932. The decrease was especially striking in those parts of Pennsylvania where in earlier years infestations of exceptional severity had prevailed, as can be seen by comparing the maps (Figs. 32 and 33).

[5]By obvious injury is meant injury visible at a glance, not requiring close examination, as when riding by in a motor car running at moderate speed.

Connected with the reduced beetle population of 1933 was the fact that in many sections no clear expansion was witnessed in that year of the area of obvious injury beyond the limits reached in 1932. This was particularly the case toward the north, where cases of obvious damage were not observed in 1933 beyond the limits (Flemington, N. J., Perkasie, Pa.) of the year before. However, in other directions an advance of the area in which such injury prevailed was indicated. Northeast, it extended into upper Middlesex (Metuchen) County, N. J., and the extreme southwestern part of Staten Island, while toward the east it extended over most of Monmouth County, reaching the coast at Long Branch, along which it extended south to Point Pleasant, Ocean County, and a few miles inland as far as Barnegat. Southeast, the same type of injury was sporadic in the Pine Barrens, though local instances were found as far as Egg Harbor City and Mizpah, Atlantic County. In general, however, the limits in this direction were rarely advanced beyond those of 1932. Farther south, however, under the influence of the exceptionally heavy infestation, which, in a measure, held its own in southern Salem and northern Cumberland County, a very considerable advance was made in 1933, instances of obvious damage being recorded in the last named county almost or quite as far south as Delaware Bay (Dorchester, Newport, Bayside).

In Pennsylvania the western limits of the area of obvious injury in 1933 advanced only a few miles beyond those of 1932, localities reached in this direction being Linfield, Montgomery County, Copesville, Chester County, and Chads Ford, Delaware County, the latter also being the limit reached in 1932. In general, obvious injury to vegetation in Delaware was, in 1933, as in 1932, limited to the eastern environs of Wilmington, but south of that city it showed some expansion, instances being noted as far west as Newport and Christiana, though cases appeared to be rare or sporadic farther west than Farnhurst and the western environs of New Castle.

Reference has already been made to the presence of an exceptionally severe infestation in Salem and Cumberland Counties in southwestern New Jersey. This is the same infestation which in the writer's former paper (1932) was mentioned as developed in 1931 in the vicinity of Elmer and Woodstown, Salem County. In that year this tract of unusually severe, or maximum, infestation was limited to the upper section of the county and scarcely extended farther south than the towns mentioned. In 1932 it had expanded southward through the same county as far as Quinton and, through northern Cumberland County, to the vicinity of Bridgeton and Shiloh. At this time the

damage to vegetation was intense, many large trees belonging to the types favored by the beetles showing all or the greater part of their foliage riddled and conspicuously discolored. In 1933, although the damage in this section was much reduced, it was still distinctly more severe than is typical of most sections of the area of obvious injury. In the same year the section in which such severe damage obtained was extended farther south, its limits in Salem County being reached at Canton and in Cumberland County at Greenwich and Fairton.

In 1931 another extensive tract of extremely heavy infestation was recorded as occurring in Pennsylvania in the section west and northwest of Philadelphia. In 1932 this tract was somewhat reduced in size and shifted a short distance farther west, the characteristic injury being displayed in northern and central Delaware County (Broomall, Wayne, Newtown Square, Media, Wawa, Glen Mills), northeastern Chester County (Centerville, Valley Forge), central Montgomery County (Norristown, Eagleville, Ambler, Lansdale, Hatfield), and central Bucks County (Doylestown, Newtown). Closely related to this was a narrow tract of very heavy damage along the Delaware River extending south in Delaware from Claymont to Edgemoor.

In 1933 the above mentioned tract of maximum infestation in Pennsylvania disappeared except for a few local remnants, all much less intense than the year before, at such places as Valley Forge, Richboro, Bucks County, Blue Bell, Montgomery County, and Wawa, Delaware County. The detached tract referred to as occurring in Delaware was still recognizable, but the damage, while severe, was much less general than in 1932.

In 1931 a third area[6] of severe infestation was indicated in eastern Mercer and southwestern Monmouth County, N. J., with its center near Allentown. In 1932 this area was still in existence and, while still recognizable at Allentown, had shifted its center farther northeast and had expanded into lower Middlesex County, where it was most clearly shown about Cranbury and Dayton. In 1933 the same area had largely disappeared south of Hightstown, but continued to be recognizable as an area of rather more severe damage than usual in lower Middlesex County, where it had expanded eastward to Jamesburg.

In 1932 other areas of quite severe damage, but of limited extent were represented in north-central New Jersey. One of these was located in northwestern Mercer County, where it was best developed about such

[6]In the writer's 1932 paper Figures 26 and 27 were unfortunately interchanged causing the map (Fig. 26) which shows the condition of the infestation in 1931 to appear to show that in 1930.

points as Washington Crossing and Pennington. In 1933 scarcely any trace was left of anything more than a very ordinary infestation in the same district.

In 1933 the only new instance that came to light in the northern section of the range of any approach to an unusually heavy infestation was a highly localized case at Jerseyville, a short distance east of Freehold, Monmouth County, N. J.

AN IMPROVED JAPANESE BEETLE TRAP

By F. W. METZGER, *Division of Japanese and Asiatic Beetle Investigations, Bureau Entomology, United States Department of Agriculture*

Many Japanese beetles are attracted to traps[1] designed to capture them, but a certain number of those so attracted do not enter these devices. Numerous tests have been conducted from year to year to increase the effectiveness of the traps in this respect and many improvements have been made. During the summer of 1933 a trap was developed which appeared to possess several advantages over those previously devised.

The trap[2] formerly recommended has a 7½-inch funnel with a screw cap at the lower end for the attachment of a beetle container. A baffle projects 4 inches above the funnel and 2 inches into it. The bait container is mounted between the wings of the baffle. Numerous beetles attracted to this trap strike the funnel and, while some of these are captured later, many are lost.

In an attempt to reduce this noneffective area, openings were cut in the funnel to allow beetles to enter below the bait container. Three types of traps with apertures in the funnel were tested; type A had 4 apertures 2½ inches square, with no extension of the baffle; type B had 4 apertures 2½ inches square, the baffle extended to the bottom of the side openings, and the flap at each aperture 1 inch long (Fig. 34); type C had 4 apertures 2½ inches long, 2½ inches wide at the bottom, and 4 inches at the top, and the flaps were 1½ inches long and projected inward at an angle of 35 degrees from the side of the funnel. This trap is illustrated in Figure 35.

At first glance this device may appear to be a modification of a trap

[1]Metzger, F. W. Trapping the Japanese Beetle. U. S. Dept. Agr. Misc. Pub. 147, 8 p., illus. June 1932.

[2]Metzger, F. W. Preliminary Tests with Liquid Bait in Japanese Beetle Traps. Jour. Econ. Ent. 26 (2): 411–414, illus. April 1933.

with a superimposed funnel, but there are two important differences. In a multiple-funnel trap there are two or more distinct funnels with a more complicated construction than in the trap illustrated. While a trap with two funnels provides a larger effective area for catching the beetles, it does not reduce the noneffective area because the lower funnel still offers a barrier, regardless of how many are placed above it.

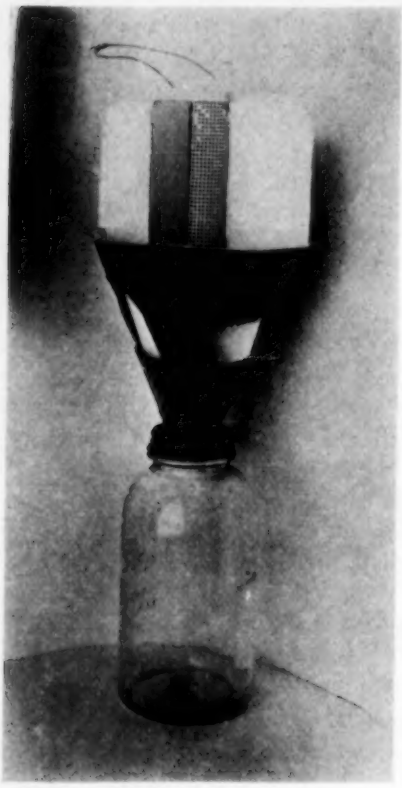


FIG. 34.—Trap A, with square side apertures.

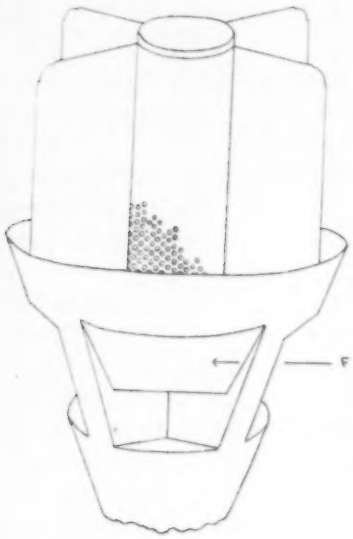


FIG. 35.—Diagram of Trap C, with side apertures larger at top than at bottom.

In each test five pairs of traps were used. The experimental trap with side apertures was located 2½ feet from the check trap, which was identical in every respect except that it had no openings in the funnel. There was an interval of 10 feet between each pair of traps. The tests were begun on June 29 and concluded on August 15. A summary of the results obtained is given in Table 1.

When trap A was tested there was a decrease of 8.7 per cent in the number of beetles captured as compared with the check. This was occasioned by the fact that the beetles entering through one side aper-

ture were able to fly out another because the baffle plates were not extended to the bottom of the opening. In addition, beetles entering the trap from above escaped through the side because the flap was not at the proper angle to precipitate them into the beetle container.

TABLE 1. SUMMARY OF RESULTS OBTAINED WITH THREE TYPES OF TRAPS HAVING APERTURES IN THE FUNNEL

	Number of beetles captured		Per cent increase (+) or decrease (—), experimental over check traps
	Experimental traps	Check traps	
(A) Baffle not extending to bottom of aperture	85,100	93,250	— 8.7
(B) Baffle extending to bottom of aperture, flap 1 inch long	285,490	276,525	+ 3.2
(C) Aperture larger at top than bottom, flap 1½ inches long	380,750	285,950	+33.1

When the baffle was extended in trap B no beetles entering the side were able to escape. By changing the angle of the flap the loss was reduced appreciably, as indicated in Table 1, since this trap captured approximately as many beetles as the check. In this trap, however, there was still an opportunity for beetles entering from above to escape by flying out through the side openings. The number lost in this manner approximated the number captured by the side entrances, so there was no increase in effectiveness.

In trap C the baffle was extended, the flap was adjusted to the proper angle, and its length was increased to 1½ inches. The openings were enlarged at the top so that their shape conformed with the sloping sides of the funnel. The four apertures of this size reduced the noneffective catching area of the trap by approximately one third. These changes in construction resulted in a considerable increase in the number of beetles captured, the difference being 33.1 per cent in favor of the experimental traps over the checks.

Numerous observations made while the traps were in the field indicated that approximately one third as many beetles were captured by entering the side as entered from the top. This indicates that practically all of those captured by the side apertures would have escaped, since 33 per cent represents the actual increase over the checks.

This trap can probably be manufactured as cheaply as a trap with no funnel apertures because this portion of the device is usually stamped out of one piece of material and no additional parts are necessary. Care must be taken, however, to insure a close fit between the edges of

the flap (F in fig. 35) and the sides of the baffle, because the beetle is very quick to take advantage of any opportunity to gain a foothold on slight projections or badly fitting joints.

THE ASIATIC GARDEN BEETLE AS A PEST IN VEGETABLE GARDENS

By HAROLD C. HALLOCK, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

The Asiatic garden beetle (*Autoserica castanea* Arrow) has caused considerable injury to ornamental plants (*2*)[1] in the vicinity of New York City over a period of years, but prior to the 1933 season it attacked vegetables only rarely. This article deals entirely with the insect as a pest in the vegetable garden.

In the period from 1927 to 1929 there was an increasing amount of leaf feeding by adults of this species on carrots, radishes, and rhubarb in gardens on Long Island near Douglaston, East Williston, and Westbury. By the end of the 1931 season (*2*) carrots were classed as a favored food plant, and parsnips and sweetpotatoes were added to the list of vegetables attacked by the beetle. During the 1931 and 1932 seasons (*3*) the larvae for the first time caused some loss in gardens at East Williston and Roslyn, N. Y., by feeding on the roots of such plants as beets, carrots, onions, and corn.

In the summer of 1933 extensive destruction by the Asiatic garden beetle occurred in vegetable gardens on Long Island. This injury was scattered over a territory extending from Flushing on the west to East Norwich on the east and from Hicksville and Rosedale on the south to the northern shore of the island.

Injury was observed in a number of home vegetable gardens, and one commercial grower lost 10 per cent of his early beets (Fig. 38) as a result of the larval feeding of this insect. The most extensive loss occurred, however, in the "Subsistence Gardens" of the unemployed. These gardens, which are scattered throughout Nassau County, N. Y., covered a total of approximately 75 acres in 1933 and ranged in size from 2 to 10 acres. The different gardens were subdivided into plots, generally 50 by 100 feet, with a variety of vegetables in each plot (*1*).

The fields, where some of these gardens were located, had not been under cultivation for a number of years, and as a result goldenrod, wild aster, orange hawkweed, snapdragon, sorrel, and plantain formed a large

[1]Numbers in parentheses refer to Literature Cited, p. 481.

part of the vegetation. As these weeds are favored food plants of the Asiatic garden beetle the fields became heavily infested with larvae. A few of the subsistence gardens had been well cultivated in 1932, and yet a considerable number of larvae were present in certain parts of these gardens.

Surveys were made in the more heavily infested subsistence gardens to determine the degree of their infestation in 1933. During June, 20

FIG. 36.—Injury to roots of peas by larvae of Asiatic garden beetle.

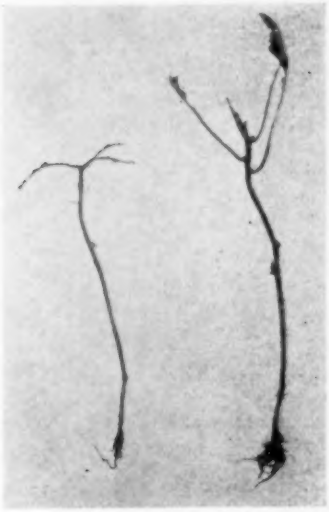


FIG. 37.—Injury to foliage of peppers by adults of Asiatic garden beetle.

diggings, each 1 foot square and 12 inches deep, were made in the sod area around the garden at Glen Head. These showed an average of 28 larvae of the Asiatic garden beetle per square foot. A more extensive survey was made in October at the heavily infested gardens. The diggings, each 1 yard square and 12 inches deep, were 75 feet apart lengthwise and 50 feet apart crosswise of the garden. At Glen Head a total of 242 square feet in the cultivated area and of 54 square feet in the sod at the side of the garden were examined. An average of 7 larvae per square foot was found in the cultivated area and 49 in the sod. At East Norwich an average closely agreeing with that at Glen Head was found in the 252 square feet examined in the cultivated area. A portion of the

garden at Locust Valley was more heavily infested than the other cultivated areas examined. There were an average of 24 larvae per square foot in the 144 square feet examined in this part of the garden. The remainder of this garden averaged 6 larvae per square foot in the 252 square feet examined. The more heavily infested area bordered on a field that was covered with goldenrod. The larger numbers of larvae in the sod were found where goldenrod or orange hawkweed were predominant in the vegetation. In the cultivated garden, larger numbers were found in the weedy areas and along the vegetable rows than in the tracts where vegetation was scanty or absent.

The spring larval feeding in the vegetable gardens started soon after the seeds sprouted and continued until the last of June. All kinds of vegetables, with the exception of onion sets, were destroyed by the larvae which fed on the plant roots (Fig. 36). The injury was so severe that it

TABLE 1. PERCENTAGE OF LARVAL INJURY IN SUBSISTENCE GARDENS

Vegetable	Approximate percentage of injury				
	East Norwich (7 acres)	Locust Valley (7 acres)	Glen Head (2¾ acres)	Green-vale (4 acres)	Sea Cliff (6 acres)
Beans	2	—	15	—	—
Beets	50	30	100	50	60
Cabbage	5	10	75	—	—
Carrots	—	—	100	—	20
Kohl-rabi	—	—	60	—	—
Lettuce	—	—	100	—	5
Onions (seedlings)	—	—	80	—	60
Peas	—	50	75	—	—
Peppers	—	—	75	—	—
Pumpkins	25	—	90	—	—
Radish	—	—	80	—	—
Squash	25	—	90	—	—
Sweet corn	—	—	80	—	—
Swiss chard	—	—	100	—	40
Tomatoes	2	5	25	—	—
Turnips	—	—	60	30	—

was necessary to reseed or reset 2 or 3 times and in some cases even to change the garden plan and use vegetables that would mature when planted after July first. Table 1 gives the approximate percentage of larval injury at the five subsistence gardens that suffered the most damage. In this table the approximate size is given underneath the name of the garden.

During the adult beetle season in 1933, the vegetables surviving the larval attack in the subsistence gardens at East Norwich, Glen Head, Locust Valley, and Sea Cliff suffered severe foliage injury. Late in the season injury to vegetables by the beetle was observed, but to a lesser extent, at the gardens located at Port Washington, Manhasset, Great

Neck, and Roslyn. Large areas were completely defoliated at the East Norwich and Glen Head gardens where the damage was more extensive

FIG. 38.—Beet field showing vacant places caused by feeding of larvae of Asiatic garden beetle on roots. An 18-inch ruler in foreground.

than at the other locations. Entire rows of carrots (Fig. 39) and turnips (Fig. 40) were completely defoliated. The leaves on large pepper plants were entirely eaten (Fig. 37), and so many plants were destroyed that extensive areas of ground were left bare. The entire heart was eaten out of cabbages, which had started to head, and the plants were ruined in most parts of those two gardens (Fig. 41).

The adult beetle has been observed to feed heavily upon the following vegetables: Beans, beets, broccoli, cabbage, carrots, eggplant, kohl-rabi, lettuce, parsley, parsnips, peas, peppers, potatoes, radishes, rhubarb, sweetpotatoes, spinach, swiss chard, and turnips. Severe injury has been observed upon many of these vegetables only when the normal favored food plants have been destroyed, as was the case in the subsistence gardens, where, in 1933, large areas containing goldenrod and wild aster had been plowed. A few of the vegetables such as carrots, parsnips,

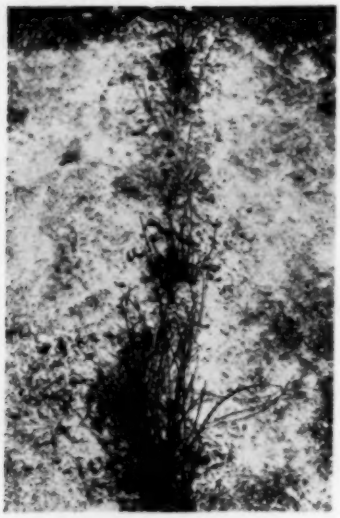


FIG. 39.—Carrot row showing defoliation by Asiatic garden beetle.

FIG. 40.—Turnip showing feeding on foliage by Asiatic garden beetle.

FIG. 41.—Cabbage field showing feeding by the Asiatic garden beetle.

turnips, beets, and peppers are favored food plants of the beetle and are often severely attacked under normal conditions.

From this year's experience it is apparent that sod areas heavily infested with larvae of the Asiatic garden beetle should not be used as a vegetable garden, since severe plant injury from root feeding must be expected. The complete elimination of all weeds in a garden by cultivation tends to reduce the larval population and thus helps to prevent the recurrence of vegetable destruction by the larvae during the following year.

In regards to the adult beetle, however, for the immediate season the destruction of the favored food plants of the Asiatic garden beetle, when there is a heavy beetle infestation in the vicinity, is apt to cause increased defoliation in the vegetable garden. Carrots, parsnips, turnips, beets, and peppers, which are favored food plants, are all liable to severe attack when grown anywhere near a heavy beetle infestation.

Literature Cited

1. Georgia, W. E., and Raymond, C. B. 1933. Subsistence gardens. Cornell Extension Bul. 253: 18 pp., illus.
2. Hallock, H. C. 1932. Life history and control of the Asiatic garden beetle. U. S. Dept. Agr. Circ. 246, 16 pp., illus.
3. ————. 1933. Present status of two Asiatic beetles (*Anomala orientalis* and *Autoserica castanea*) in the United States. Jour. Econ. Ent. 26: 80–85, illus.

Japanese scale, *Leucaspis japonica* **Ckll.** This insect has been established along the coast in southern New England and southeastern New York for a number of years. It is decidedly local and ordinarily not particularly injurious. There has developed within the last few years a general infestation of soft maples at Freeport, L. I., many of the smooth-barked, large limbs being encrusted with the scales of this insect. Red maple and Norway maple are also badly infested. Apple trees, pear trees and flowering dogwood growing near the soft maples were likewise found thickly infested. An examination in April, 1934, showed relatively few, partly grown, living scale insects, the species evidently having suffered a heavy mortality as a result of the extreme cold of the past winter. This insect is not nearly so injurious to the cambium of badly affected areas as in the case of the San Jose scale, *Aspidiotus perniciosus* Comst., which latter also suffered a heavy mortality the past winter. There are reports of a number of soft maples having been removed in this Village, and it is quite within possibilities that this somewhat recently introduced scale insect has been more injurious to its hosts than has commonly been supposed.

E. P. Felt

SMALL MAMMALS AS PREDATORS ON JAPANESE BEETLE GRUBS

By ROBERT J. SIM, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

Several small mammals are known to be more or less constant burrowers in the soil, and it was thought likely that some of these might be economically important as destroyers of larvae of the Japanese beetle, *Popillia japonica* Newm. With this in view, certain observations and experiments have been made at odd times during the past year. Only the more noticeable species found in the Japanese beetle area are dealt with in this paper.

So far as we have learned, the moles and shrews are insectivorous and carnivorous, the former entirely subterranean in habits, the latter largely so. The mice, on the other hand, are rodents and to a large extent vegetarian in their diets. In general habits they vary. One species lives almost entirely under ground and has somewhat molelike modifications in structure. Three species spend more of their time in runways just at the surface, but under vegetable litter and rubbish. Three other species of mice—all long-tailed—are usually above ground. But all of our mice at times work below the surface. The efficiency of small quadrupeds as predators of scarabaeid larvae usually depends upon the degree to which a given species is subterranean in its habits.

All of the animals here considered masticate their food thoroughly; so the examination of stomach contents was considered impracticable in this case. We can not follow the feeding activities below ground; therefore feeding experiments were conducted with caged individuals of as many species as were available. Within a few days nearly all of them became fearless enough to take food from the hand and finish their meals under observation.

One common mole, *Scalopus aquaticus* (Linn.), was kept for several days. This animal fed willingly upon bits of raw beef. Earthworms also were taken, but after eating three or four the mole became indifferent. Japanese beetle grubs were snatched up with avidity, chewed down quickly, and accepted continuously about as fast as they could be supplied. The apparent preference of grubs to other sorts of food was demonstrated repeatedly.

The work of moles in a half acre of lawn was observed throughout the part of the past year when the ground was not frozen. The animals worked back and forth, just beneath the surface while grub hunting, eventually covering practically every foot of ground. It is true that the

moles at times make unsightly piles and ridges of fresh earth on the lawn, but they do not allow the beetle grubs to become numerous enough to cause browning. The common mole is abundant in the sandy soil characteristic of the higher parts of the coastal plains.

The star-nosed mole, *Condylura cristata* (Linn.), is prevalent in lower ground where the soil is constantly somewhat moist—as along stream and pond margins or the borders of mucky meadows. The work of this peculiar species has been seen in lawns and gardens bordering streams, but no feeding experiments have been possible thus far. It is probable that the star-nose moles eat Japanese beetle grubs wherever their usual habitats overlap.

The short-tailed shrew, *Blarina brevicauda* (Say), is the largest and most generally distributed of its group in this district. All the shrews are high-strung, delicately organized creatures, difficult to trap alive or keep in captivity. However, by constant attention to the traps and with subsequent care, three individuals of this large species were caught and are now doing well in captivity. They require a great amount of food, and are kept supplied with bits of raw beef, liverwurst, Japanese beetle grubs, and squash seeds. They seem fond of all these things, but always attack the grubs with most enthusiasm. From 15 to 30 seconds are required for eating one grub. Each shrew will eat from 10 to 20 of the larvae before getting enough for one meal. In an hour or less it is dinner-time again! In view of the great though generally unsuspected abundance of this species, it is undoubtedly an important factor in keeping down the population of white grubs and allied forms.

We turn now to a consideration of the rodents. Among these the pine mouse, *Pitymys pinetorum scalopsoides* (Audubon and Bachman), is probably the most frequent feeder upon grubs. It is very abundant in fields and gardens where the ground is somewhat sandy and dry. A powerful digger, with good musculature, small eyes, and fine mole-like fur, it is well adapted to its subterranean life. Five individuals were kept in captivity for several months and were thoroughly tried out as to food preferences. They were always well supplied with such vegetable foods as would be accessible to them in nature, but in spite of this they always accepted Japanese beetle larvae—each mouse devouring about a half dozen grubs at one sitting. While generally undesirable on the farm and in orchards, it seems likely that the pine mouse should be known as a predator on scarabaeid beetles in their early stages.

The Pennsylvania meadow mouse, *Microtus pennsylvanicus* (Ord.), the largest of our short-tailed mice, is abundant in low or wet fields throughout the Eastern and Middle States. It lives in runways mostly

just at the surface—in short, it occupies the ground floor above the basement apartments of the star-nosed mole. This common field mouse is largely a feeder upon the sedges and grasses of its natural habitat. Two individuals kept under observation for some weeks would accept beetle grubs occasionally, but showed no eagerness for them. This species under certain conditions makes some inroads on farm products. At the same time its importance as a destroyer of noxious insects is probably negligible.

The red-backed mouse, *Clethrionomys gapperi rhoadsi* (Stone), is numerous along wooded streams and in cedar swamps of the pine-barren region of the coastal plains. In these places its runways and tunnels often form a network through or beneath the sphagnum and vegetable litter. In feeding habits it seems to be chiefly herbivorous. Six redbacks were kept several months for observation. They would eat but two or three *Popillia* grubs each, at any one time, but were always hungry for various seeds, nut meats, cranberries, apples, and the stalks of certain grasses. Considering the nature of its habitat and its food preferences, the red-backed mouse is likely of little significance as an insectivore.

The white-footed or deer mouse (*Peromyscus leucopus* and vars.) is abundant in woods and thickets throughout the Eastern and Middle States. It often frequents farm buildings, camps, and cabins and sometimes comes into houses to spend the winter. It occasionally lives in a short burrow in the ground, but more often has its home in a log, a hollow tree, or an abandoned birds' nest. It excels in scansorial ability and is not infrequently seen climbing about in shrubs and trees. A dozen specimens kept in captivity for several weeks became quite fat on a mixed diet of insect and vegetable foods. Although constantly supplied with seeds, nut meats, and apples, the mice always crowded around when lepidopterous pupae were put into the cage. The tough silk cocoons of the *Promethea* and *Cecropia* moths were ripped open with great dexterity and the contents soon eaten. The pupae of the oriental fruit moth were extracted from their cells with movements too quick for the eye to follow. Six or eight Japanese beetle grubs would be eaten by a single mouse, but that seemed to be enough for any one meal. From these observations it would appear that the deer mouse is a considerable factor in the suppression of certain insects. Owing, however, to its rather limited fossorial tendencies, it is probably only an accidental feeder upon *Popillia* grubs.

The house mouse, *Mus musculus* Linn., long ago introduced from Europe, is a familiar winter pest in our buildings, but during the warmer

months it is usually out in the fields. The nest is sometimes built in a small underground chamber beneath an old pile of cornstalks or other neglected fodder. This species may follow the general trend among rodents and eat some insects (other than pinned specimens!), but one full-grown mouse kept for several days refused to eat any grubs at all.

The jumping mouse (*Zapus hudsonius* and var.) usually haunts old fields of broom grass near "spungs" or low spots. It hibernates during the winter in a subterranean cell dug by itself; but during the wakeful season the so-called kangaroo mouse travels about through its grassy habitat feeding perhaps on weed seeds and probably some insects. Its well-developed leaping ability is used at its best only in emergencies. One large hibernating female dug from a sandpit was brought in November 22, 1933. It soon became active and was supplied with a variety of food. Nut meats, cheese, and liverwurst have been ignored; an apple has been eaten to a slight extent only, though it has been in the cage for several days. But from the first this mouse eagerly accepted Japanese beetle grubs whenever they have been offered. The anterior half of each larva is eaten and the remainder dropped. From ten to twenty are so treated before the mouse retires for a sleep. It may be that the jumping mice are more insectivorous than has been supposed.

The Lemming mouse, *Synaptomys cooperi* Baird, is apparently confined to the more remote sphagnum-carex bogs of the Pine Barrens. Its known food consists of the succulent stems of certain grasses and sedges. The usefulness of this mouse as an insect predator is doubtless rather questionable.

Finally we come to the largest and apparently the most diligent of the quadrupeds that prey upon scarabaeid larvae; the skunk, *Mephitis nigra* P. and B. While practically omnivorous, the skunk has long been recognized as a hunter of white grubs. During October of this year an individual was observed almost daily digging in a grub-infested lawn near Valley Forge. The holes made were numerous, but scarcely larger than those of the starling, and not conspicuous enough to disfigure the turf. The animal was indifferent to human proximity, and divided his time by alternately rooting diligently for a while then curling up for a nap and sun bath on the lawn. It appears that in many localities skunks are increasing in numbers, and when not otherwise objectionable are sometimes valuable allies in our battle with *Popillia japonica*.

From the foregoing notes it will be seen that the majority of our small terrestrial mammals are more or less enthusiastic feeders upon Japanese beetle larvae and similar forms. Of those herein considered, the common mole, the large short-tailed shrew, the skunk, and perhaps the pine mouse are in this way the most important.

NOTES ON THE LIFE HISTORY AND BIOLOGY OF *CENTETER UNICOLOR* ALDRICH

By L. B. PARKER, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*[1]

Centeter unicolor Ald.[2] first came to the attention of the writer, as a parasite of *Anomala sieversi* Heyd. and *Phyllopertha pubicollis* Waterh., in the spring of 1931 when he was engaged in collecting *Tiphia vernalis* Roh. at Suigen, Chosen (Korea), for shipment to the United States. A preliminary study of the life history was begun at this time and continued in the spring of 1932.

HOST OCCURRENCE AND HABITAT.—The two hosts, *A. sieversi* and *P. pubicollis*, may be found in the field at Suigen from the last week in April through most of the month of May, though *P. pubicollis* precedes the former in time of appearance and disappearance in the field.

Though both species of beetles may be found in the same localities, each one exhibits a preference for a different type of floral environment. Consequently, parasitized beetles of the two host species were collected from two different localities. That in which *P. pubicollis* was most abundant was an area lightly wooded with oak, pine, and chestnut, and with a sprinkling of spirea and willow, all situated between orchards of peach and pear. At the time the collections were made a number of trees and shrubs were in bloom, spirea and oak being those favored as food plants by *P. pubicollis*, and it was from these blossoms that the parasitized beetles of this species were collected. The parasitization here was not heavy, being 27.2 per cent, the number of parasite eggs per beetle rarely exceeding 3. Attempts to study the adult parasite in this locality were abandoned, as the large numbers of active insects visiting the blossoms here rendered observation extremely difficult.

In the locality where *A. sieversi* was the predominating host species, the flora consisted chiefly of pine, oak, and chestnut, growing sparsely on grassy knolls separated by various distances across cultivated land. Here, owing to their greater numbers and to less distraction by other insects, the adult parasite could be observed with comparative ease. In this particular locality the parasitization at the time the observations were made, was 73.6 per cent, the greater portion of the parasitized beetles bearing more than 3 eggs each and some individuals as many as

[1]The writer is indebted to Messrs. R. W. Burrell and K. Sato for assistance in obtaining material for study. The original drawings are the work of Mr H. Sugiura.

[2]Aldrich, J. M. Five New Parasitic Flies Reared from Beetles in China and India. No. 2753. Proc. U. S. Nat. Mus. 74, Art. 8: 1–7. 1928.

33. The degree of parasitization throughout this region was extremely variable, the percentage just mentioned being the maximum observed.

EGG PLACEMENT.—The parasite normally places its egg ventrally on the posterior portion of the abdomen of the host, but eggs are commonly found on other portions of the body, particularly the legs and dorsally on the thorax and exposed portions of the abdomen. The writer has never observed an egg to be placed upon the head of the host and has witnessed but one instance where it occurred on an elytron. Successful entrance by larvae into the body of the host has been observed, from eggs placed on the thorax and abdomen (dorsally and ventrally), on the softer tissues between two abdominal sclerites, and on the femora. Entrance into the tibia has been noted also, but definite proof of further progress of the larva was not obtained.

THE EGG.—The egg measures approximately 0.7 mm. in length by 0.5 mm. in width by 0.25 mm. in thickness. When first laid it is a creamy white, turning darker with age. The chorion is tough and leathery rather than brittle or papery. The egg is firmly held in position on the derm of the host by a secretion which forms a transparent membrane across the bottom of the egg and a narrow irregular border around it.

Incubation of the egg and entrance into the body of the host requires approximately 4 to 5 days, depending upon prevailing temperatures and the position of the egg upon the host. Death of the beetle normally follows oviposition in 6 to 8 days and pupation occurs about 4 days later. Hence the period from oviposition to pupation of the parasite is approximately 12 days. In cases where the host is penetrated by numerous larvae, death would doubtless occur in a much shorter time.

THE LARVA.—The first-instar larva is approximately 1.0 mm. long. As in the case of *C. cinerea* Ald., it enters the host by means of a small hole drilled through the sclerite immediately beneath the egg. There is no external evidence that the egg has hatched other than a pronounced darkening, which distinguishes it from unhatched eggs. For the purpose of effecting an entrance into its host, the mouth parts of the first-instar larva are modified to form a curved tool having saw-like teeth which enable the otherwise delicate maggot to penetrate the heavy exoskeleton of its host. The caudal spiracles in this instar are small and inconspicuous.

The second-instar larvae possess the mandibular hooks common to dipterous larvae of this type. The caudal spiracles are prominent and resemble those of the second-instar larva of *C. cinerea* in that each has a sharp hook-like process protruding from it. According to Clausen,

King, and Teranishi,[3] these hooks on the larvae of *C. cinerea* probably serve to perforate and to attach the body temporarily to one or more of the numerous air sacs within the body of the host, thus providing a means of respiration for the parasite.

The mouth parts of the third-instar larva are similar to those described for *C. cinerea*;[3] however, the hypostomal sclerite in lateral view (Fig. 42 D) is strongly hooked ventrally. The caudal spiracles are prominent and are characterized by a trilobed appearance and three spiracular openings (Fig. 42 E), instead of four openings as in the case of *C. cinerea*.

It is difficult to say what the precise movements of the larva may be after entering the body of the host, for larvae of varying ages were found in different positions. As many as 10 early instar larvae have been found in one host beetle, but in the material handled by the writer no more than 2 were known to pupate in the same host.

Apparently the feeding first takes place in the abdomen, the larva gradually working its way toward the anterior end, eventually devouring the contents of the thorax and head and returning to the abdomen to pupate.

THE PUPAL STAGE.—The pupal stage requires approximately 10½ months. Formation of the dark reddish-brown pupa (Fig. 42 F, G, H) normally occurs in the abdomen of the host, but in the course of the writer's experiments it was found that when two sections of a beetle were partially severed from each other the mature larva emerged through the opening and pupated successfully, either on the surface of the soft soil provided, or, in some cases, after penetrating to a depth of 1 to 4 inches. Emergence of the adult fly from laboratory reared puparia was obtained, but the method of exit from the shell of the host was not observed.

THE ADULT FLY.—The adult fly (Fig. 42 A) appears in the field at approximately the same time as its host and, like *C. cinerea* as a parasite of *Popillia japonica* Newm., reaches the peak of its parasitism and disappears from the field in advance of its host, the period of field prevalence being approximately 25 days.

The normal food of the fly is honeydew and the nectar of various blossoms, while in the laboratory a solution of honey and water was acceptable. Apparently the adults are very susceptible to desiccation, as the rate of mortality in the rearing cages was high wherever the moisture pad provided was not replenished daily. Under laboratory

[3]Clausen, C. P., King, J. L., and Teranishi, C. The Parasites of *Popillia japonica* in Japan and Chosen (Korea) and Their Introduction into the United States. U. S. Dept. Agr. Bul. 1429, 56 p., illus. 1927.

conditions none of the adults lived longer than 6 days, while the adult longevity in the field, though not known, is estimated at about 2 weeks.

Attempted mating has been observed in reared flies soon after emerg-

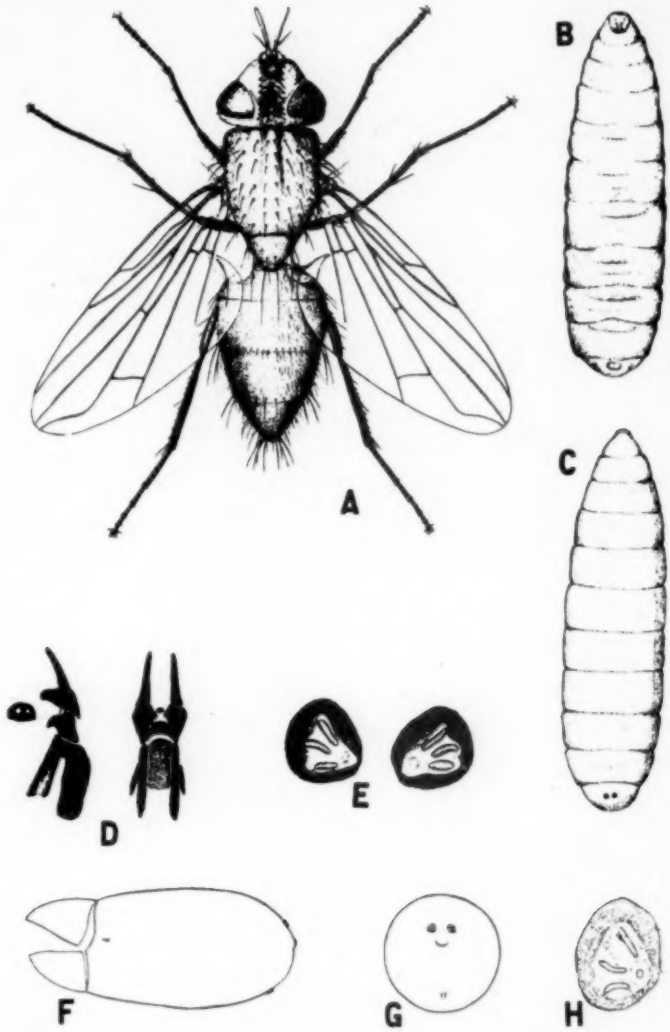


FIG. 42.—*Centeter unicolor* Aldrich. A—Adult female. B—Third-instar larva (ventral view). C—Third-instar larva (dorsal view). D—Mouth parts of third-instar larva. E—Caudal spiracles of third-instar larva. F—Puparium (lateral view). G—Puparium (caudal view). H—Caudal spiracles of pupa.

ence, but the earliest successful union noticed occurred between two individuals on the second day after their emergence and lasted for a period of 42 minutes.

The flies are more easily observed in the field during the morning hours of an overcast day. At such a time the host is less active than on bright days with higher temperatures, and thus becomes an object for more successful attack by the fly. The writer has frequently been attracted to the position of one or more host beetles by the number of female flies hovering above the particular twig or branch on which the beetle rested.

After selecting its intended victim, the fly alights in the immediate vicinity and may or may not proceed directly to the attack. Once the attack has begun, the entire process is marked by the absence of any haste or sudden movement on the part of either parasite or host. In fact, the calm and deliberate determination of the fly is almost ludicrous as it spars with the slowly waving legs of its prey.

Before proceeding to the attack the fly raises herself on her legs, permitting the abdomen to be curved under and forward until the tip is directly under her head. Then, without otherwise touching the host, she extends her ovipositor slightly in advance of the rest of her body and endeavors to attach an egg to the ventral side of the abdomen. The approach is first made from the rear of the beetle, which, if it senses danger, pushes the fly to one side with a thrust of the hind legs. If repeated attack from this angle proves unsuccessful, the fly may retire a short distance and wait for the beetle to become quieted before resuming operation. It is not unusual for a fly, in avoiding the defensive activity of the beetle, to be forced to approach from another direction. In the opinion of the writer, such tactics, rather than the presence of previously laid eggs on the posterior venter of the host, account for the misplacement of a large number of eggs.

In one instance observed in the field, a beetle, becoming sufficiently disturbed by the persistence of its enemy, began to crawl along the twig upon which it was resting, followed by the fly at a distance of about 3 inches. The fly manifested no intention of overtaking its quarry, but when the beetle, on reaching the end of the twig, turned and started back, the fly came to a halt. Then, as the beetle approached her, she stepped to one side and deftly deposited her egg laterally upon the beetle as it passed. Having completed oviposition, the fly wiped her abdomen and ovipositor with her hind legs and flew away.

Oviposition was obtained in the laboratory under very abnormal conditions. The equipment used was a glass cylinder 4 inches long by

1½ inches in diameter; it was closed at one end and contained a few chestnut leaves, the open end being covered by a piece of muslin cloth.

The total number of mature eggs developed by one female is not known. In dissecting gravid, field-collected females the maximum number of mature eggs found in one individual was 24, while 11 others were sufficiently well formed to be segregated from the mass of undeveloped buds. In the case of laboratory-reared flies, 20 was the maximum number of eggs sufficiently well developed in 2-day-old females for accurate counting.

THE STATUS OF *TIPHIA VERNALIS* ROHWER, AN IMPORTED PARASITE OF THE JAPANESE BEETLE, AT THE CLOSE OF 1933

By J. W. BALOCK, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*[1]

Tiphia vernalis Rohwer, a larval parasite of the Japanese beetle, was introduced into this country in 1924 (*1*).[2] It was first liberated in 1925, evidence of establishment was obtained in 1927, and it was definitely proved to be successfully established in 1928. In its native habitat this parasite has for its normal host *Popillia castanoptera* Hope, but under laboratory conditions it has accepted, as hosts, the larvae of four species of *Popillia* (*2*), and also the larvae of *Anomala orientalis*.

LIFE HISTORY AND HABITS.—In the latitude of Philadelphia, *Tiphia vernalis* adults are found in the field from late April until early June (April 28 to June 6, 1933). The males emerge first, and by the time the first females are seen, which is about 3 or 4 days later, the males are very abundant. The peak of female abundance is not reached until about the 19th of May. The parasite is a blossom and honeydew feeder, and in this country is frequently found on the foliage of maple and cherry. Mating takes place early in the field, apparently as soon as the females emerge, for rarely are any of the early females seen that are not mating. When ready to oviposit, the female *Tiphia* burrows into the ground and, after locating the host larva, stings it ventrally in the mid-thoracic region. This paralyzes the grub temporarily, and while it is in this condition the parasite places an egg on the grub in the ventral groove

[1]The author acknowledges the assistance rendered in various phases of this work by J. L. King, in charge of parasite investigations, and T. R. Gardner, M. H. Brunson, R. W. Burrell, R. T. White, and L. B. Parker, members of the staff.

[2]Italic numbers in parentheses refer to Literature Cited, p. 496.

separating the third thoracic and first abdominal segments. The egg is pearl white when first laid, but turns darker before hatching. The length of the egg stage is 9 to 10 days, and of the larval stage about 20 days. The parasite larva feeds externally by sucking the body juices from the living host grub until within a few days of the end of its feeding period, by which time the weakened host dies. The parasite completes its feeding on the dead host, which it consumes entirely except for the hard, sclerotic parts. It then spins a cocoon suspended in the soil cell formerly occupied by the host grub. The parasite continues to develop inside the cocoon and by late fall becomes an adult, in which stage it overwinters within the cocoon.

IMPORTATIONS.—*Tiphia vernalis* was first imported into this country in the cocoon stage. From 1924 to 1927, 21,221 cocoons were received and 1,265, or 5.9 per cent, were successfully reared. Because of the unsatisfactory results obtained from the importation of cocoons, this method of introduction was abandoned and shipments of adults were begun in 1926 (*3*). To date, 69,175 female adults have been shipped from Chosen (Korea) and 47,413, or 68.5 per cent, were received alive. During the past few years the shipping technique has been improved to such an extent that, out of 36,748 females shipped between 1930 and 1933, 31,930, or 86 per cent of them, were received in an active and healthy condition.

Table 1 gives in detail the nature of the *Tiphia vernalis* shipments and the number of adults obtained from them.

TABLE 1. SHIPMENTS OF COCOONS AND ADULTS OF *Tiphia vernalis* AND PERCENTAGES AVAILABLE FOR COLONIZATION

Year	Number of female adults shipped	Number of female adults received alive	Per cent of female adults received alive	Number of cocoons shipped	Number of adults reared	Per cent of adults reared
1924.....	———	———	—	5,348	116	2.1
1925.....	———	———	—	5,997	275	4.6
1926.....	4,325	454	10.5	6,720	607	9.0
1927.....	9,868	5,211	53.0	3,156	267	8.4
1928.....	7,249	1,555	21.4			
1929.....	10,985	8,263	75.2			
1930.....	6,960	6,175	88.7			
1931.....	5,718	5,259	92.0			
1932.....	11,678	10,259	87.8			
1933.....	12,392	10,237	82.6			
Total or average	69,175	47,413	68.5	21,221	1,265	5.9

COLONIZATION.—The first liberation of *Tiphia vernalis* in this country was made in 1925 near Moorestown, N. J., and consisted of a few adults reared from the cocoons received in 1924. This colony was reinforced

in 1926 with 4,301 *Popillia* larvae parasitized under laboratory conditions and planted under the sod. These parasitized grubs were obtained in rearing experiments conducted with females from imported cocoons received in 1925, and from shipments of adults received in 1926. In 1927, 4 additional colonies were released at separated points, both female *Tiphia* and parasitized grubs being used. In 1928, 1929, and 1930, 16 new colonies were started entirely from imported females. In 1931, 10 colonies were started with imported females and 1 colony with females collected locally from a colony started in 1927.

Until 1932 Chosen was the only source from which *Tiphia vernalis* could be obtained in sufficient numbers for colonizing purposes. However, by that year the colony at Philmont, Pa., which had been started in 1927 with 1,170 females and 4,534 parasitized grubs, had become so well established that it could be used as a collecting ground for *Tiphia* adults for the further dissemination of parasites throughout the area of heavy Japanese beetle infestation. The method of collection was to attract them from the open fields, hedgerows, and forest borders by spraying a solution of equal parts of honey and water on the lower branches of trees, where they could be easily captured. In the more open areas, where suitable shrubs and trees were not readily available, it was found advantageous to stick small, leafy branches into the ground at convenient collecting points and to spray them with the honey solution. Both males and females were attracted to the honey-coated foliage in large numbers. It was only necessary to collect the females for subcolonization purposes, however, as *T. vernalis* females mate very shortly after emergence and their fertilization is thus practically certain.

The females are readily distinguished from the males by their larger size and more robust form, and, as they are somewhat less active than the males, they are easily collected individually in glass tubes. These tubes are 3 inches long by 1 inch in diameter, one end being closed with plaster of paris and the other end with a cork. The plaster of paris both absorbs and holds moisture, and thus keeps the vial from sweating and yet retains sufficient moisture in the air of the tube to keep the wasp alive.

The females collected are examined to check species identity and sex, and then transferred in units of 100 each to tin containers, 6 inches in diameter by 10 inches in depth, each container being supplied with soil, food, and water.

In 1932 three men collected 4,608 *Tiphia* females in 12 days at the Philmont colony, and in 1933 two collectors took 5,391 females from the same location in 11 days. Two other colonies, both originally colonized

in 1929, showed a marked increase in *Tiphia* population in 1933. These locations were also used as collecting sources and 1,527 females were obtained from them by two collectors working an aggregate of 17 days. Collections were made on favorable days between 8.00 A. M. and 3.30 P. M. Although females of *Tiphia vernalis* are present in the field from early May to early June, the peak of abundance is not reached until about May 19, and it is during the week preceding and the one following this date that the females can be most profitably collected.

Table 2 summarizes the collecting data for the past two years.

TABLE 2. COLLECTIONS OF *Tiphia vernalis* IN THREE LOCALITIES IN PENNSYLVANIA IN 1932 AND 1933

Year	Locality	Number of females collected	Number of collectors	Number of days worked	Total number of man-hours worked	Average number of females per man-hour
1932	Philmont, Pa.	4,608	3	12	150	30
1933	Philmont, Pa.	5,391	2	11	125	43
1933	Roxboro, Pa.	879	1	9	38	23
1933	Overbrook, Pa.	648	1	8	27	24
Total		11,526	7	40	340	33

Females collected locally were liberated in units of 100 the day following their capture in the field. In the case of imported females, a certain amount of time was required for unpacking and preparing the shipment for liberation, including transfer to freshly prepared containers, and counts to determine the number surviving. Generally, about 2 days elapsed between the time the shipment was received and its liberation. Inasmuch as shipments of adults usually arrived late in the season when a large percentage of the host grubs were in the prepupal and pupal stages, and the females had only a limited period in which to work, liberations had to be made in large numbers in selected areas where host conditions were most favorable. The number of imported females liberated at one location varied from 200 to 1,000, depending upon host conditions at the time the parasites were received.

TABLE 3. LIBERATIONS OF *Tiphia vernalis* FROM IMPORTED AND LOCALLY COLLECTED FEMALES FROM 1926 TO 1933

Year	Imported females	Locally collected females	Total
1926	1	0	1
1927	4	0	4
1928	2	0	2
1929	7	0	7
1930	7	0	7
1931	10	1	11
1932	13	45	58
1933	41	66	107
	85	112	197

Colonies were placed at locations that met as nearly as possible the following requirements: (1) An abundance of host grubs; (2) proximity to food plants; (3) high and low land to insure a good grub population during both wet and dry years. The location of each new colony was recorded accurately on a topographic map. The dates of liberation, grub concentration, and other pertinent data were recorded on separate cards for each new location. This method of recording parasite liberations greatly facilitated recovery work. Table 3 shows the number of colonies started from both imported and locally collected females between 1926 and 1933.

FIG. 43.—Present distribution of *Tiphia vernalis* in the area of heavy Japanese beetle infestation: Black circles, colony locations; broken line, area of heavy Japanese beetle infestation.

THE PRESENT STATUS OF THE COLONIZATION PROJECT.—At the present time there are 197 colonies of *Tiphia vernalis* in the field (Fig. 43), 85 colonies from imported females and 112 from females collected locally during the past three years. During 1933, 31 colonies that were two years old or older were scouted, and 22, or 70 per cent, were recovered. Whether these figures are indicative of what may be expected from the more recent liberations remains to be seen. However, 67 per cent of the colonies put out in 1932 and 1933 were started with locally collected females, and the chances for successful establishment of these colonies should be increased, as these females have a longer season in which to work and are younger and more vigorous than imported females when placed in a new colony center.

It is difficult to predict the future value of this parasite or even to determine its present value accurately. It is known to be established in at least 22 locations, and to be abundant at 6 of these places. Because of the gregarious habits of *Tiphia vernalis* and its slow rate of spread, the immediate problem is to augment the spread of the parasite over as wide an area as possible by extensive colonization. On account of the large area over which the Japanese beetle is now distributed and the comparatively recent establishment of *Tiphia vernalis* over a small portion of that area, whatever part the parasite may be playing in control is thus far strictly local. Diggings conducted in 1933 over a limited area at Overbrook, Pa., which was colonized 4 years ago, in 1929, indicated a parasitization of 7.4 per cent. This was based on 46 diggings, 1 foot square and the examination of 214 grubs. During the same year 9 diggings of 1 square foot each at the Philmont, Pa., colony gave 39 cocoons. The diggings were made in October and comparing the cocoons found with the average grub concentration of 15 grubs per square foot in May, which is the time when *Tiphia vernalis* seeks its host, these figures would indicate a parasitization of 28.8 per cent over a limited area.

LITERATURE CITED

1. 1928. ALLEN, H. W., and JAYNES, H. A. Progress with the Imported Parasites of the Japanese Beetle during 1927. Jour. Econ. Ent. 21: 823–832, illus.
2. 1927. CLAUSEN, C. P., KING, J. L., and TERANISHI, C. The Parasites of *Popillia japonica* in Japan and Chosen (Korea) and Their Introduction into the United States. U. S. Dept. Agr. Bul. 1429, 56 p., illus.
3. 1931. KING, J. L. The Present Status of the Established Parasites of *Popillia japonica* Newman. Jour. Econ. Ent. 24: 453–462. illus.

COMPARATIVE OVIPOSITION EFFICIENCY AND COLLECTION COSTS OF IMPORTED VERSUS ESTABLISHED *TIPHIA VERNALIS* ROHWER, A PARASITE OF THE JAPANESE BEETLE

By T. R. GARDNER, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

Tiphia vernalis Rohwer, a parasite of the Japanese beetle, was first imported in the adult form into the United States from Chosen (Korea) in 1926. Shipments of adults have been continued each year to the present time (1933) and the females have been used in colonizing the heavily infested areas of New Jersey and Pennsylvania. With improved shipping methods and food, considerable success has been attained in transporting this parasite, and the mortality en route as compared with that of the earlier shipments has been materially reduced. The number of days that the females are confined in the shipping containers from the time of collection in Chosen to the time of arrival at Moorestown, N. J., ranges from 20 to 33. This variation in time is due mainly to the infrequent steamer sailings from Japan, which are from 1 week to 10 days apart. In the shipments of 1931 the mortality en route was 8.1 per cent, in 1932 it was 12.2 per cent, and in 1933 it was 17.4 per cent.

By 1932 a number of colonies of this parasite had been established in New Jersey and Pennsylvania through the importation of adults. However, only one colony, located at Philmont, Pa., was sufficiently large to supply females for recolonization. In 1933 three additional colonies had increased enough in population to supply females for recolonization in the Philadelphia area.

COMPARATIVE OVIPOSITION EFFICIENCY.—On June 12 a shipment of 10,237 live females arrived at Moorestown, and from them 75 females were selected at random for the experiment. These females had been confined in the shipping containers with food and water from the time of collection in Chosen to the time of release in the United States. They had been subjected to the disturbing influences of changes in temperature and handling encountered on train and steamer. Each female was placed with four Japanese beetle grubs and soil in an oviposition can measuring 2½ inches in diameter and 2 inches in depth. The grubs were separated by cross sections of 6-mesh wire screening 1½ inches in depth, which kept them from attacking and biting one another and yet allowed the parasite to pass freely from one compartment to another in the soil in search of the grubs on which it might oviposit.

A small piece of waxed paper holding a drop of water and a pellet of powdered sugar mixed with honey was placed on the soil for the parasite to feed upon. Each day the contents of the cans were emptied and the grubs examined for parasitization. The parasites were again placed in the cans with new grubs and fresh soil and food. This operation was repeated until all the *Tiphia* had deposited their eggs and died.

On May 11, nine days after the first female was recorded in the field, 75 females were collected at the Philmont colony. These were placed with grubs in oviposition cans and examined each day in the same manner as the imported material. The oviposition cans of both imported and native material were kept at a constant temperature of 73° F., which is the optimum temperature for oviposition of this species.

The total number of eggs deposited by the imported females was 2,882, giving an average of 38.4 eggs per female, while the total number deposited by the native females was 4,479, giving an average of 59.7 eggs per female. The average length of life of each imported female from the time of collection to death was 51 days, of which an average of 25 days was spent in the oviposition cans. The average length of life of each native female from the time of collection to death was 38 days, all of which was spent in the oviposition cans. The longer length of life of imported material is attributed mainly to the low temperatures at which the females were stored during transportation. If, for the purpose of comparison in this experiment, we assume that the oviposition efficiency of native collected females is 100 per cent, then the oviposition efficiency of imported females is 64.3 per cent.

Comparative Costs.—In computing the comparative costs of collecting imported and native females, all expenses were taken into consideration except the salaries of the supervising technical men, who were regular Government employees carrying on other lines of entomological research at the same time. The expense of collecting imported material included the salaries of one Japanese assistant and several Chosenese collectors, the assistant's per diem allowance while in the field, his railroad and steamship fare from Japan to Chosen and return, the cost of shipping cases, cans, and food, and the express charges on the shipment from Chosen to Moorestown, N. J. The expense of collecting native material included the salaries of several collectors, mileage on one automobile from the laboratory to points of collection and return, and bridge toll across the Delaware River.

The time devoted to the collection of material in Chosen covered approximately 3 weeks, while the time devoted to the collection of native material covered approximately 2 weeks.

In 1931 the cost of importing 5,259 females was 6.85 cents per female; in 1932 the cost of importing 10,259 females was 2.18 cents per female; and in 1933 the cost of importing 10,237 females is estimated[1] at approximately 1.99 cents per female. The costs of these importations are based on the number of *Tiphia* arriving at Moorestown alive. The cost of collecting 4,608 females from the established colony at Philmont was 3.34 cents per female in 1932, and in 1933 the cost of collecting 6,918 females from locally established colonies was 2.56 cents per female. No females were collected from locally established colonies in 1931.

These figures show that the actual cost of collecting foreign material was 1.99 cents per female as compared with 2.56 cents per female for locally collected material in 1933. Since this year's study shows that the oviposition efficiency of the 1933 shipment was only 64.3 per cent as great as native material, it may be assumed that the cost of imported material amounted to 3.09 cents per female.

The cost of collecting material in Chosen in 1931 was more than three times as great as in the following two years. This may be explained as follows: In 1931 the Japanese yen was worth about 49 cents in United States currency, but in 1932 and 1933 it dropped to approximately 23 cents, thus cutting collecting expenses to less than half; nearly twice as many females were obtained in 1932 and 1933 as in the previous year, which further reduced the cost per female, since most of the expenses are incidental but necessary to the actual cost of collecting. These incidental expenses remain about the same each year regardless of the number of *Tiphia* collected.

Importations of adult *Tiphia vernalis* have been continued to the present time, largely because the locally established colonies have not developed sufficiently to supply enough females for recolonization in the constantly increasing area of heavy infestation by the Japanese beetle. However, it is felt that further importations are no longer necessary, as several locally established colonies are now sufficiently large to supply material for recolonization purposes.

[1]Actual cost figures for 1933 are not yet available and this estimate is based on the money allotted for the work.

THE EFFECTIVENESS OF PARADICHLOROBENZENE AND NAPHTHALENE IN PREVENTING OVIPOSITION BY THE JAPANESE BEETLE

By J. WILLIAM LIPP,[1] *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

In February 1932 a number of tests were conducted, the results of which indicated that a thin layer of paradichlorobenzene crystals on the surface of the soil in 4-inch pots was very toxic to third-instar Japanese beetle larvae with which the pots had been previously infested. During July of the same year tests were run to determine what effect the vapor might have upon eggs laid in pots which prior to oviposition had been treated with paradichlorobenzene in the same manner. An examination showed that no eggs had been laid in the treated pots and that the soil contained a large number of dead beetles, whereas there were many eggs in untreated pots that had been set up at the same time. It was evident that in the treated pots the beetles had been killed before they could oviposit.

The results obtained with paradichlorobenzene suggested that perhaps there were other chemicals that would prevent oviposition. Accordingly, a number of chemicals were selected for testing. The results of tests conducted with anthracene and naphthalene during July 1933 showed that anthracene had little value in preventing oviposition but that naphthalene gave very good results. Since both paradichlorobenzene and naphthalene looked so encouraging, it was decided to devote the remainder of the summer to a study of these two materials and to defer the testing of other chemicals until the next season.

OUTDOOR TESTS WITH PARADICHLOROBENZENE AND NAPHTHALENE.—Since the tests already described had been run under insectary conditions, outdoor tests were conducted in which beetles were given the opportunity to oviposit in both treated and untreated soil. Seven rows of seven 4-inch pots were plunged in the ground and a thin layer of paradichlorobenzene crystals was scattered over the surface of the soil in alternate pots. All the pots were then covered with a half-inch layer of untreated soil. A wire cage, 3 feet square and 1 foot high, was then placed over these pots and in this cage approximately 400 beetles were confined for 1 week.

The number of eggs subsequently found in each pot is indicated in the

[1]The writer wishes to thank C. H. Hadley and W. E. Fleming for their helpful suggestions in the preparation of this paper.

following diagram, the eggs in the untreated pots being printed in italics:

0	*6*	0	*9*	0	*12*	0
42	0	*19*	0	*10*	0	*11*
0	*35*	0	*1*	0	*8*	0
113	0	*12*	0	*12*	0	*17*
0	*41*	0	*3*	0	*5*	0
132	0	*29*	0	*9*	0	*16*
0	*156*	0	*56*	0	*3*	0

It can be seen that no eggs were found in any of the treated pots. In practically all these pots, however, dead beetles were found, varying in number up to 54 per pot, although in no case was a beetle found below the layer of crystals.

The following results were obtained in a similar test in which naphthalene crystals were used instead of paradichlorobenzene:

0	*36*	0	*40*	0	*1*	0
5	0	*22*	0	*9*	0	*18*
0	*20*	0	*10*	0	*11*	0
23	0	*41*	0	*5*	0	*11*
2	*28*	3	*22*	4	*36*	0
116	3	*28*	0	*35*	0	*49*
21	*228*	8	*189*	2	*61*	0

Although naphthalene was not entirely effective in preventing oviposition, considerably fewer eggs were laid in the treated than in the untreated pots, the average being 1.7 per pot in the former and 43.5 per pot in the latter.

LENGTH OF THE PERIOD OF EFFECTIVENESS.—The volatility of both paradichlorobenzene and naphthalene suggested that after a period of time the crystals would have evaporated, with the consequent loss of effectiveness in preventing oviposition. To determine how long the chemicals would be effective, 10-inch pots were nearly filled with soil, the soil was watered to compact it, and 1 or 2 ounces of either paradichlorobenzene or naphthalene was applied to the surface and covered with a ½-inch layer of soil. These pots, together with a number of untreated soil-filled pots, were placed in a screened slat cage. After various intervals a treated and an untreated pot were removed from the slat cage and plunged in the ground under a cage of the type described in the preceding section, where they were subjected to oviposition by field-collected beetles. The treated pot was placed in the southwest corner of the cage and the untreated pot adjacent to it along the west side. The treated pot was thus subjected to a very severe test, as previous experiments had shown that in a cage of this type between 50 and 60 per cent of the eggs were found in the southwest quarter, the corner pot containing the largest number. At the end of 7 days the pots were re-

moved and the soil was examined carefully for eggs. Each dosage of each material was tested separately with a treated and an untreated pot for each test. For each test a new cage with a fresh supply of beetles was used.

The 1-ounce treatment with paradichlorobenzene prevented oviposition for 18 days. The pot subjected to oviposition on the 18th day after treatment and examined on the 25th day contained 67 eggs, while the untreated pot contained 42 eggs.

Pots with 2 ounces of paradichlorobenzene were subjected to infestation on the 11th, 18th, 21st, and 25th days after treatment and examined, respectively, on the 18th, 25th, 28th, and 32nd days after treatment. No eggs were found in any of the treated pots, while the untreated pots contained from 87 to 143 eggs.

When 1 ounce of naphthalene was used, 15 eggs were found in the pot subjected to infestation on the 11th and examined on the 18th day after treatment, whereas the untreated pot contained 85 eggs. The treated pot subjected to infestation on the 18th day contained 9 eggs, while the untreated pot contained 91.

With a 2-ounce dosage of naphthalene similar results were obtained as with 1 ounce up to 18 days, but a pot subjected to oviposition 21 days after treatment contained no eggs when examined 1 week later, while the untreated pot contained 117 eggs. In two tests with pots subjected to infestation 25 days after treatment one treated pot contained 1 egg while the untreated pot in the same cage contained 186 eggs, and in the other cage the treated pot contained no eggs while the untreated pot contained 112 eggs.

It will be noted that of the pots subjected to infestation on the 18th day after treatment with 1 ounce of paradichlorobenzene more eggs were found in the treated pot than in the untreated pot, whereas in the pots receiving the same dosage of naphthalene the number of eggs in the treated pots was markedly reduced. When a 2-ounce dosage of naphthalene was used oviposition was not entirely prevented until 21 days had elapsed between treatment and subjection to infestation. The slower rate of evaporation of naphthalene may explain the apparent increase in efficiency of the chemical with the increase in the length of time between the date of treatment and the date of subjecting the pot to infestation. Some time must elapse before the concentration of the naphthalene vapor in the soil layer above the crystals has been built up to the point where it is able to kill the beetle entering the soil to oviposit, and since the naphthalene evaporates more slowly than the paradichlorobenzene, the vapor formed passes from the soil more slowly.

A PRELIMINARY REPORT ON THE HORIZONTAL MOVEMENT OF GRUBS OF THE JAPANESE BEETLE

By I. M. HAWLEY, *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

From time to time grubs of the Japanese beetle (*Popillia japonica* Newman) are found in locations under field conditions that raise the question as to how far they are able to move horizontally in the soil. For example, in cultivated fields grubs are often present in large numbers around corn, lettuce and strawberry plants, and yet are scarce in the fallow ground between rows of these plants. In some cases they congregate around buried stones and other objects when the surrounding soil is quite free of them. If the grass in one part of a heavily infested lawn is killed, grubs become less abundant there, but increase in numbers beyond the edge of the killed-out area. Cases of this kind have led to the conclusion that grubs do move horizontally in the soil, but as to just how far they travel it has been possible only to surmise.

In the first migration tests grubs were placed in bins that would permit a horizontal movement of 2 feet, but, as many readily covered this distance, a new test was started in which a movement of as much as 4 feet was made possible. In this, as in all subsequent tests, a bin 8 feet long and 4 feet wide was filled to a depth of at least 1 foot with sieved, sandy loam. All the tests were carried on during the winter in a heated greenhouse with grubs collected in the field as they were needed; therefore, the movement may not be entirely comparable to that found under field conditions. One hundred fullgrown field-collected grubs were placed at a depth of 3 to 5 inches in a narrow trench across the middle of the bin, and in the last foot of one end wheat was grown to determine whether more grubs moved toward the wheat than went in the opposite direction. At the end of 36 days the bin was examined, and 98 of the 100 grubs were recovered. Of these 58 were found to have moved toward the wheat and 40 in the opposite direction. Apparently, therefore, the presence of the wheat had some slight influence on the direction taken by the grubs. Of the 98 grubs recovered, 8 had travelled more than 46 inches, 26 more than 40 inches, and 70 more than 20 inches. Grubs were found at all depths from 1 to 14 inches, but it is interesting to note that of 31 grubs found in the upper 2 inches of soil, 24 were found among the roots of the wheat.

Since 8 of the grubs in the test described moved over 46 inches, it was evident that the possible distance to travel must be increased still more, and a new experiment was started permitting a movement of 7 feet. In

each of two bins, 8 by 4 feet, 100 grubs were placed in a trench 1 foot from one end. In the last foot of the opposite end of each bin wheat was planted. As the migration in the two bins was quite similar, the findings in the two tests are combined. In 37 days, 7 of 161 grubs recovered had moved more than 80 inches, 20 more than 60 inches, 50 more than 40 inches, and 78 more than 20 inches. Many remained near the starting point or had moved toward the nearer end of the bin, only 1 foot away. Six grubs had travelled through 6 feet of fallow ground and 1 additional foot planted to wheat and had reached the far end of the bin. It is probable, therefore, that in a larger bin some of the grubs would have travelled still greater distances.

As grubs, under normal conditions, are more abundant in lawn turf and meadows than in any other situation, it seemed advisable to compare the movement in grass sod with that which had been found in fallow ground. The two bins previously used were prepared as before, with the exception that in one a good stand of grass was grown, while in the other the ground was allowed to lie fallow. In each bin 100 grubs were placed in a trench 1 foot from one end. After 37 days the soil in the bins was removed, and it was found that of 92 grubs recovered in the grass bin, 1 had moved more than 80 inches, while 3 of 79 in the fallow bin had covered this distance. In the grass bin 4 had travelled more than 60 inches as compared with 18 in the fallow bin, while only 5 had moved more than 40 inches through grass as against 33 under fallow conditions. Only 10.2 per cent of the grubs that moved toward the far ends of the bins travelled more than 40 inches in sod as compared with 63.5 per cent that moved more than this distance in fallow ground. As in the previous test, many were found near the starting point or in the opposite end of the bin. In the grass bin 95.6 per cent of the grubs were among the grass roots in the upper 5 inches of soil, while only 16.5 per cent were above this depth in the fallow bin. Incidentally it was found that 17 of the grubs that had grass available as food had changed to the prepupal condition, but none of those in fallow ground had made this change.

It should be noted that the distance from the starting line to the point at which grubs were found may represent in many cases only a fractional part of the distance travelled, since a study of grub movement in other experiments has shown that grubs do not as a rule move in a straight line for any great distance, but rather tend to change their course, in some cases even doubling back in the direction from which they came.

The finding of greater movement by grubs in fallow ground than in

sod is not surprising, as the main incentive to move about is, no doubt, the desire to find succulent food, and unless the food supply is lacking, or has been destroyed by intensive feeding or some other cause, there is little reason for a change of position.

In conclusion it may be said that under greenhouse conditions grubs have moved horizontal distances as great as 7 feet, which is as far as the bins used in the tests would permit. However, an experiment has now been started in two field cages where grubs will have a chance to move much farther than the bins in the greenhouse would permit. There was considerable individual variation in the distances travelled, but the tendency to move about is much more evident in fallow ground than in grass sod.

CODLING MOTH SITUATION IN VIRGINIA

By W. J. SCHOENE, *Entomologist Virginia Agricultural Experiment Station*

During the past season the codling moth has caused very serious losses in many parts of the state. In some orchards the injury has been so severe that the trees bore no marketable fruit. In a few orchards as high as seven poison sprays were applied. The codling moth injury became apparent in these severely injured orchards in July when from thirty to fifty per cent of the apples were marked with stings. We have always had more or less injury and in some localities there has been a gradual accumulation due to insufficient equipment or omission of sprays, but for the most part the worm damage in well sprayed orchards has been negligible.

I want to outline briefly, first; the events preceding the outbreak, second; summarize the injury and third; discuss the recommendations for next season.

Just a word about the apple situation in Virginia. The commercial apple industry in Virginia has depended largely on out-of-state markets for the sale of its apples. In former years about 40% of the crop normally moved to foreign countries, and a considerable portion to the Southern States. Since only apples of good quality can be shipped out, the low grade fruit with stings, scab, etc., had no value. Accordingly our research and educational program has been developed for the purpose of increasing the percentage of number one apples.

EVENTS PRECEDING THE OUTBREAK.—We have had several seasons when the weather was favorable for codling moth development. There has been no short crop since 1927. That means that the worms have

had ample food since 1928. This is important, because a short crop reduces the worm population. The dry weather in 1930 and 1932 prevented the apples from attaining full size with the result that there were many small apples. These were left in the orchard and there was consequently a larger accumulation of worms than would ordinarily occur. Then too, the attitude of our Virginia growers should be mentioned. There have been no similar outbreaks in this state. The three or four poison sprays have been keeping the insect under control. Supplementary measures such as banding the trees, the use of codling moth traps, have not been necessary. In recent years the growers have purchased larger spray machines and more spray has been applied, although there is still a shortage of spray equipment in many orchards. The most important event in connection with the outbreak is the spray schedule adopted in 1926. When the Food and Drug Division made the first regulation regarding arsenic we recommended a spray schedule providing for three poison sprays for the first brood and one spray applied at the beginning of the second brood. The purpose of this schedule was to attack the codling moth early in the season with a hope that the insect would be held in check and there would be no serious residue on the fruit at picking time. Our growers did not want to purchase washing machines and furthermore, in many localities water was not available for washing. When the residue situation first arose the washing machine had not been developed to meet our condition where the fungicide is combined with the poison. Even with this revised spray schedule the worms were generally held in check except where the sprays were omitted or where the work was carelessly done. The next important event was the switch to calcium arsenate which was substituted for arsenate of lead in the last two sprays when the ruling on lead tolerance went into effect. We had a special spray schedule to be used where the apples were to be washed. Lastly it is believed that the codling moth worms are becoming more resistant to poison, which fact coupled with the revised spray schedule, the annual crops and the dry weather of previous seasons, has led up to the present outbreak.

Statement Regarding Injury.—We have in Virginia, orchards that are always wormy due to careless spraying or mismanagement. In one such orchard, the codling moth bands on some trees were found to harbor more than a thousand worms, while in some well sprayed orchards it was usual to find several hundred worms in each band. During recent weeks examinations have been made of orchards in different sections of the state. It has been found that there is a great difference in the infestation, oftentimes in orchards belonging to the same owner. Some

orchards had a clean crop of high grade fruit, free from worms, whereas, others in the same locality were almost a total loss. The reason for this difference in infestation in different orchards is not entirely apparent. It seems that while in some cases the spraying may have been in fault, this does not explain the difficulty. It is suspected that the failure to adequately spray the tops of the large trees has made it possible for the first brood worms to develop in such numbers that they were not held in check by later sprays. In the Roanoke section the type of packing house has evidently been responsible for a heavy carry-over of worms from the autumn of 1932. In all of the orchards studied the most serious injury has occurred near the packing house. In these orchards the trees located in the part of the orchard some distance from the packing shed have been injured much less. After a study of a good many orchards it is believed that the outbreak is not due to the shortage of spray materials or to the spray schedule but to heavy carry-over of worms from last season. Also, the method of handling fruit at picking time tends to concentrate the worms at the packing shed. For the most part these buildings are open structures which provide a satisfactory hibernation place for the worms. It appears that the outbreak in the summer of 1933 was due to the presence of large numbers of worms overwintering from the latter part of the season of 1932, and since this outbreak occurred in the early season, it occurred before the calcium arsenate sprays were applied.

RECOMMENDATIONS.—Some of our growers are keenly alive to the situation. They realize that they must stop the codling moth or they will soon be out of the apple business. A full program of operations is being prepared. For this winter we are recommending (1) scraping and pruning of trees, (2) clean-up of packing house, (3) pasturing the orchard with sheep or hogs, and (4) housing the picking boxes in a tight room. For next season a special spray schedule is being prepared and in addition the use of tree bands will be urged.

It has been suggested that as soon as the apple harvest was completed that the trees should be scraped and a careful search made for worms. It is recommended that the trees be opened up by pruning and that all crevices and cracks be filled. The picking equipment such as boxes, barrels, etc. was found to harbor many worms. The growers are urged to put all of the picking boxes into a tight room where they will remain until needed again next year. If this is done, the worms which have spun cocoons in these boxes will mature in due season but the moths being unable to escape from the room will not return to the orchard. One grower has undertaken to dip the crates in boiling water

A packing house clean-up is being urged. It is suggested that all the paper, leaves, etc., around the packing shed be removed and burned and that every effort be made to reduce the number of worms that might remain over the winter in the building. If possible, the building should be made tight to prevent the escape of the moths. It is believed some growers will remove the packing house to some point outside of the orchard.

Many of our Virginia growers made a practice of turning sheep or hogs into the orchard after the apples have been harvested. The effect on codling moth is doubtful, however, this is urged wherever the orchard is fenced. The animals will consume apples left on the ground, eat the grass and weeds and possibly reduce the number of worms.

In the past a spray schedule has been recommended which would leave such a small amount of spray residue on the apples at picking time that washing would not be necessary. But, for these orchards where the codling moth has not been controlled, a full arsenate of lead program will be recommended, with the expectation that acid washers will be available for cleaning the fruit. The lead arsenate sprays will be recommended for both the first and second brood worms and in addition the use of codling moth bands will be urged. It will be urged that trees near the packing shed should be double sprayed and that more effort be made to apply the poison to the top and inside of the tree.

Many of our Virginia growers make a practice of thinning their fruit and a few have been able to cut down the codling moth infestation during the thinning operations by collecting and destroying the infested apples.

In conclusion it is believed that the present outbreak is traceable in part to the favorable weather and to abbreviated spray schedule and that the abundance of worms in most orchards dates from the summer of 1932. The method of handling the apples and the location of the packing houses has been undoubtedly favorable to the codling moth. Drastic measures will be required to again reduce the worms to the point where the ordinary sprays will hold them in check.

NOTES ON CODLING MOTH CONTROL IN 1933

By ERNEST N. CORY[1], *State Entomologist, College Park, Md.*

The codling moth situation in Maryland varied from very bad on the Eastern Shore to normal conditions in Western Maryland when the commercial grade of the fruit is considered. The highest average injury in the state occurred this year in Central Maryland. The average infestation for the whole state was 8.7 per cent, and the average stings for the entire state 29.9 per cent, based on a total of 32 commercial orchards. On the Eastern Shore we had one orchard where the percentage of stings ran as high as 65.1 and the percentage of worms in the same orchard 10.1. These averages, with other difficulties taken into consideration, left only 20.5 per cent clean fruit for this orchard. This rating is closely approached by one orchard, No. 5, in Central Maryland where there was 12.24 per cent worms and 18.41 per cent stings, and these injuries, coupled with heavy aphis injury, resulted in reducing the clean fruit to 24.95 per cent. The highest average of wormy fruit in the central district was 37.31 per cent worms and 15.12 per cent stings. However, this orchard omitted the first, third and fourth cover sprays.

Owing to the arsenical tolerance and the lack of funds most orchards in the state omitted the fourth cover spray. Had this spray been applied by July 15, the probabilities are that a much higher percentage of worm-free fruit would have been produced. A majority of the growers in the state used calcium arsenate in the third cover spray and many of them used it in the second cover spray. In the orchard in Western Maryland where the best codling moth control was obtained, only one calcium arsenate spray was applied, the application being made between June 22 and July 1. The following table of results shows the comparison between calcium arsenate and lead arsenate in worm con-

TABLE 1. RESULTS OF CALCIUM ARSENATE AND LEAD ARSENATE SPRAYS ON STAYMAN AND YORK APPLES

	A. Calcium arsenate			B. Lead arsenate		
Orchard No.	Per cent clean	Per cent stings	Per cent worms	Per cent clean	Per cent stings	Per cent worms
1	48.0	25.0	2.8			
2	20.5	65.1	10.1	28.6	54.3	13.5
3	62.2	21.3	5.6	61.3	21.2	7.8
Average	43.5	37.1	6.1	44.9	37.7	10.6

[1]The records upon which this article is based were obtained by the following men: H. S. McConnell, working at College Park, C. Graham in the Western Maryland area, D. H. Brannon, working in Central Maryland, and S. L. Crosthwait on the Eastern Shore.

trol in two orchards on the Eastern Shore, the comparisons lying between orchards No. 2 and No. 3. Orchard No. 1 was sprayed throughout the season with calcium arsenate. The control in the orchard that used calcium arsenate throughout compares very favorably with plots in which lead arsenate was used up to the time of the last cover spray, followed by calcium arsenate in the last spray.

In Central Maryland we have only one orchard that used calcium arsenate throughout the season with the exception of the pre-pink spray, when arsenate of lead was used. This orchard showed the lowest proportion of wormy fruit, 4.08 per cent, and the next to the lowest percentage of stings, 6.37. Orchard No. 2 in the central district, which used arsenate of lead throughout, had a slightly greater injury from codling moth than Orchard No. 5 previously mentioned, where calcium arsenate was used throughout. The results in the two orchards that completed the spray schedule through the third cover spray, substituting calcium arsenate in the second and third cover sprays, do not present anywhere near as significant results in codling moth control as in Orchard No. 5. This might be explained in part by less efficient spraying. The control in these two orchards averaged over one-half as efficient in the control of actual wormy apples and slightly less than one-third as efficient in the control of stings.

The orchard in the western section that has used calcium arsenate consistently for the past three years used one arsenate of lead spray as a first cover application, and because so much injury was done by the calyx spray it was thought best to change to arsenate of lead. However, this first cover spray of arsenate of lead gave equally as much injury as the calcium arsenate sprays so that the season was finished with calcium arsenate. In this orchard a high degree of worm control has been obtained for many years and this year the percentage of worms was 3.9 and the percentage of stings was 1.2 in one variety and 9.6 per cent of worms and 2.2 per cent of stings in another variety. One orchard in this district that used a central spraying system had an average of 2.1 per cent worms for six plots in three varieties and a percentage of stings for the same plots of 1.67. The average percentage of fruit free from codling moth injury for all Western Maryland orchards was 89.2. In the orchards belonging to the American Fruit Growers, where arsenate of lead was used through the season with the exception of the last cover spray, in which calcium arsenate was used, there was 96.76 per cent worm-free fruit. An application in one of these orchards of an arsenate of lead-oil spray on August 15 in addition to the regular schedule mentioned above shows an average of 5.17 per cent worms in the blocks of

two varieties receiving this additional spray as against 7.5 per cent worms on blocks that did not receive the additional spray. In the matter of stings this experiment showed an average of 3.8 per cent for the sprayed blocks, and an average of 3.05 per cent for the check plots.

TABLE 2. SUMMARIZED RESULTS WITH CALCIUM AND LEAD ARSENATE IN THE CONTROL OF CODLING MOTH AND CURCULIO AT HANCOCK, MARYLAND, 1933

Materials used	Per cent fruit free from moth and curculio injury	Per cent worms	Per cent stings	Per cent curculio
2 lbs. calcium arsenate used with sulfocide	84.49	12.3	3.13	.8
3 lbs. calcium arsenate used with sulfocide	84.30	10.7	3.6	1.4
2 lbs. calcium arsenate used with lime sulphur	82.21	13.6	3.9	.29
3 lbs. calcium arsenate used with lime sulphur	84.48	12.5	2.5	.52
3 lbs. arsenate of lead used in pink, petal fall, and 1st cover. 2nd cover 2 lbs. calcium arsenate	89.03	7.4	3.1	.47

There was a trace of burning with all of the combinations used in the pink application. This was not serious enough to be of any importance and the calcium arsenate plots were no worse than the lead arsenate plots.

EXPERIMENTAL WORK AT COLLEGE PARK.—Nine plots were sprayed with the following schedules:

TABLE 3. TESTS OF VARIOUS ARSENICALS FOR THE CONTROL OF THE CODLING MOTH

Plot No.	Spray materials used	Variety	Number fruits examined	Per cent of Clean	Wormy	Stings	Burn
1	Delayed dormant—oil Pink—lime sulphur and lead Calyx—no spray at all 1st cover (1 week late)—lead, lime sulphur amd nicotine 2nd and 3rd cover—Calcide and Bordeaux and calcium caseinate	Delicious	341	62.4	5.9	14.1	9.1
2	Delayed dormant—oil Pink—lime sulphur and lead Calyx—no spray 1st cover (1 week late)—lead, lime sulphur and nicotine 2nd and 3rd covers—lead, Bordeaux and calcium caseinate	Stayman	410	70.2	5.1	9.3	10.8
3	Delayed dormant—oil Pink—lime sulphur and lead Calyx—no spray 1st cover (1 week late)—lead and lime sulphur and nicotine	Stayman	254	55.1	3.9	22.8	5.1

TABLE 3. *Continued*

Plot No.	Spray materials used	Variety	Number fruits examined	Clean	Per cent of Wormy	Stings	Burn
3	2nd and 3rd covers—Calrox and Bordeaux and calcium caseinate						
4	Delayed dormant—oil						
	Pink—lime sulphur and lead						
	Calyx—no spray						
	1st cover (1 week late)—lead and lime sulphur and nicotine	Nero	362	52.8	*	6.6	7.4
	2nd and 3rd covers—zinc arsenate and Bordeaux and calcium caseinate						
5	Delayed dormant—oil (Cresoil except on Staymans)						
	Pink—lime sulphur and lead	Stayman	353	46.9	1.7	13.3	10.8
	Calyx—no spray						
	1st cover (1 week late)—lead and lime sulphur and nicotine	York	827	62.3	4.2	17.8	5.2
	2nd and 3rd covers—zinc arsenate and Bordeaux and summer scalecide						
6	Delayed dormant—Cresoil (except Stayman)						
	Pink—lime sulphur and lead	Grimes	675	51.9	8.7	21.0	14.0
	Calyx—no spray						
	1st cover (1 week late)—lead and lime sulphur and nicotine	Stayman	365	39.4	2.2	16.0	10.1
	2nd and 3rd covers—Copper arsenate and Bordeaux and fish oil						
7	Delayed dormant—oil						
	Pink—lime sulphur and lead						
	Calyx—Lead and lime sulphur and calcium caseinate (Only part of row) (Severe burning)	Grimes	737	64.2	7.2	7.1	4.7
	1st cover (1 week late)—lead and lime sulphur and nicotine	York	552	45.8	7.6	16.5	11.0
	2nd and 3rd cover—Calcide and magnetic sulfur and summer scalecide						
8	Delayed dormant—oil						
	Pink—lime sulphur and lead	Grimes	708	38.3	13.8	29.6	8.3

*Only six wormy apples.

8	Calyx—Calcide and lime sulphur and fish oil (Severe burning)	York	716	55.2	11.6	17.2	39.5
	1st cover (1 week late)—lead and lime sulphur and nicotine	Stayman	291	46.4	8.6	21.6	8.2
	2nd and 3rd covers—Calrox and Bordeaux and fish oil						
9	Delayed dormant—oil						
	Pink—lime sulphur and lead						
	Calyx—Calcide and lime sulphur and calcium caseinate (severe burn)	York	1241	47.9	12.2	25.1	3.2
	1st cover (1 week late)—lead and lime sulphur and nicotine	Stayman	433	55.0	5.3	14.8	11.3
	2nd and 3rd cover—Calrox and Bordeaux and calcium caseinate						

The results from these plots show a general advantage for the complete lead treatment over any other combination. The wormy percentage in this plot was 5.1, the stung fruit 9.3, and spray injury 10.8. The plots receiving no calyx spray and using calcium arsenate gave 4.9 per cent wormy, 18.45 per cent stings and 7.1 per cent spray injury. The plots in which a calyx spray of arsenate of lead with calcium arsenate in the subsequent sprays gave an average of 7.4 per cent worms, 11.8 per cent stings, and 7.85 per cent spray burn. Plots in which a calyx spray of calcium arsenate followed by a calcium arsenate-Bordeaux-fish oil schedule gave 11.4 per cent worms, 19.4 per cent stings, and 18.7 per cent spray injury. In similar plots with calcium caseinate used in place of fish oil, the worms amounted to 8.7 per cent and stings to 19.9 per cent and the spray burn to 7.02 per cent. Zinc arsenate used in two plots, in one of which calcium caseinate was used as an adhesive, and in the other a summer oil, showed decided advantage for the calcium caseinate. The average worm infestation was 1.4 per cent, stings 11.0 per cent, and the spray burn 7.7 per cent. Scheeles Green used as a poison in similar plots gave 5.04 per cent wormy fruit, 18.5 per cent stings, and 12.0 per cent injury.

It is very difficult to generalize on the basis of this season's experimental work. The weather was decidedly favorable for spray injury and the weathering-off of spray mixtures, which would normally be expected to create conditions unfavorable to calcium arsenate. On the whole, however, calcium arsenate gave relatively satisfactory results where it was used consistently and thoroughly. Lead arsenate about measured up to the normal expectations, but the fear of excess spray

residue led many growers to curtail their programs. Of the substitute arsenicals, zinc arsenate showed considerable promise in a rather limited plot work. This material came on the market late and it was not possible to get any large scale experiments under way.

The relatively high percentage of infestation in many orchards will no doubt lead to much more general washing of fruit, thereby permitting more thorough and later applications of poison.

THE FLUCTUATION OF THE POPULATION OF *TIPHIA POPILLIAVORA* ROHWER IN THE FIELD AND ITS POSSIBLE CAUSES

By M. H. BRUNSON,[1] *Division of Japanese and Asiatic Beetles, Bureau of Entomology, United States Department of Agriculture*

Tiphia popilliavora Rohwer, a larval parasite of the Japanese beetle (*Popillia japonica* Newm.), was imported from Japan in 1920 and liberated the following year at Cinnaminson, N. J.[2] In 1927 the parasite was sufficiently abundant at the original points of liberation to warrant the collection of females for redistribution. A total of 191 colonies, each containing 100 females, were liberated between 1927 and 1931. Recoveries have demonstrated the ability of the parasite to establish itself in this new environment and to multiply rapidly under certain conditions. Seasonal observations of some of the more promising colonies, however, show that there is a marked fluctuation of the adult population from year to year. From 1930 to 1933 experiments were conducted in an effort to ascertain the environmental conditions that affect this fluctuation.

An indication of the fluctuation in the population of *T. popilliavora* is given by the number of females collected for colonization. In 1927 collections at Cinnaminson totaled 1,100; in 1928, 4,400; in 1929, 10,100; and in 1930, owing to the scarcity of females, only 510 were taken. In 1931 collections at Cinnaminson and Columbus, N. J., and Ogontz, Pa., totaled 4,905, and in 1932 no more than a dozen females were seen at each of these points. Adults were fairly abundant in 1933 at many colony points, but little increase was noted at the three colonies mentioned.

[1]The writer acknowledges with appreciation the data furnished by Henry Fox relative to the population of Japanese beetle grubs and the assistance rendered by J. L. King in the preparation of this paper.

[2]King, J. L., and Holloway, J. K. 1930. *Tiphia popilliavora* Rohwer, a parasite of the Japanese beetle. U. S. Dept. Agr. Circ. 145, 12 p., illus.

VARIATIONS IN HOST POPULATION.—In 1929, the year preceding the first decline in the number of *T. popilliavora* at Cinnaminson, the grub population in New Jersey during the latter part of August was very low, averaging only 3.1 per square foot, whereas in 1927 it was 10.1 per square foot and in 1928 it was 16.9 per square foot. The dry weather prevailing in 1929 was unfavorable to a numerous and general distribution of the grub population. The grubs were restricted to low, damp areas, while the activities of *T. popilliavora* were confined primarily to the higher elevations. The greatest apparent environmental change was in the number of the host grubs. Therefore, it was concluded that this was the primary, if not the only, cause for the decline in the population of *T. popilliavora* in 1930 in the vicinity of Cinnaminson.

The slight increase in the number of adult parasites at the Cinnaminson colony in 1931 was no doubt due to a more general distribution of the host grubs the previous year. Since 1931 there has been a low grub population in this locality and very few *T. popilliavora*.

ADAPTATION OF PARASITE TO THIRD-INSTAR HOST GRUBS.—The scarcity of the host grubs was not the cause of the small number of *T. popilliavora* at Columbus and Ogontz in 1932, as surveys showed grubs to be abundant and well distributed the previous year, except in the vicinity of Cinnaminson. In an effort to explain this variation in the parasite population, attention was turned more to its adaptation to development on host grubs in different stages that were available for parasitization at the time the parasite was present in the field.

T. popilliavora adults are present in the field in greatest abundance during August. During this period the host grubs occur in three different stages of development, namely, the three larval instars. The percentages of grubs occurring in each of the three instars at four stations in New Jersey during August 1932 and 1933 are shown in Table 1.

TABLE 1. THE PERCENTAGES OF JAPANESE BEETLE GRUBS IN EACH OF THE THREE INSTARS IN NEW JERSEY DURING AUGUST 1932 AND 1933

Year	Instar	Percentage of grubs		
		August 1–10	August 11–20	August 21–31
1932	First	50.5	18.3	5.2
	Second	49.3	79.8	66.3
	Third	0.1	1.8	28.4
1933	First	55.2	39.7	23.7
	Second	44.5	59.0	51.0
	Third	0.2	1.2	25.2

It was found in Japan that *T. popilliavora* would accept second- and third-instar grubs of the beetle for oviposition but that the parasites

would develop to adults only on the grubs in the third instar.[3] Observations in this country have shown that the parasites would not accept first-instar grubs for oviposition but would accept second- and third-instar grubs and that the parasites would develop to adults on both of these stages.

In an effort to ascertain a possible preference by female parasites for second-instar or third-instar grubs for oviposition and the normal development of the parasite to the adult stage, individual females were confined in 6-ounce tin boxes with both second-instar and third-instar grubs. In 1932, 26 females were confined approximately throughout their lifetime, each in a container divided into four compartments. In each of these compartments two grubs, one of each instar, were placed. The containers were supplied daily with fresh food for the parasite and with fresh grubs, the parasitized grubs being removed for cocoon formation. In this observation 1,178 parasitized grubs were obtained, of which 991 were in the third instar and 187 in the second instar. The ratio of third-instar to second-instar grubs parasitized was 5.3 to 1. In 1933, 26 females were used in a similar experiment, but the methods were slightly different. The container in which the females were confined had eight compartments instead of four, and one host grub was placed in each, the two instars being alternated. The separation of the grubs and the alternation of their two instars gave a more accurate comparison of host selection, as the females came in contact with only one grub in each compartment. In this observation 368 grubs were parasitized, of which 348 were in the third instar and 20 in the second instar. The ratio of third-instar to second-instar grubs was 17.4 to 1.

In 1932, from 1,125 third-instar grubs that had been parasitized in the laboratory, 710 cocoons, or 63.1 per cent, were obtained; and from 556 parasitized second-instar grubs 245 cocoons, or 44.1 per cent, were obtained. In 1933, from 350 parasitized third-instar grubs, 204 cocoons, or 58.2 per cent, were obtained; and from 1,022 parasitized grubs, practically all of which were in the second instar, 458 cocoons, or 44.8 per cent, were obtained.

These observations show that the females prefer grubs in the third instar for oviposition, and also that the parasite larvae develop to the cocoon stage most readily on third-instar grubs. In the absence of third-instar grubs, however, second-instar grubs are readily accepted by females and the daily oviposition rate is little different, if any, from

[3]Clausen, C. P., King, J. L., and Teranishi, C. 1927. The parasites of *Popillia japonica* in Japan and Chosen (Korea) and their introduction into the United States. U. S. Dept. Agr. Bul. 1429, 55p., illus.

that when females are placed with grubs that are all, or practically all, in the third instar. The difference in the oviposition rate and the development of parasite larvae to the cocoon stage on grubs in the two instars is not sufficient to explain the failure of colonies in areas where there is a scarcity of third-instar grubs.

ADULT EMERGENCE FROM HOST GRUBS OF DIFFERENT SIZES AND INSTARS.—The study was continued by observing adult emergence from cocoons obtained from grubs of different sizes and stages of development. In 1931 emergence from cocoons from grubs of the same instar but differing in size was compared. The parasites emerged from cocoons formed in 1930 in rearing experiments conducted by J. K. Holloway to determine the relative number of cocoons formed on large and small second-instar grubs. The adult emergence in 1933 from cocoons formed on second-instar and third-instar grubs was the final result of a study begun in 1932 comparing the ability of the parasite to develop on these two stages. The results are shown in Table 2.

TABLE 2. ADULT EMERGENCE FROM COCOONS OBTAINED FROM HOST GRUBS OF DIFFERENT SIZES AND INSTARS IN 1931 AND 1933

Year	Host	Host grubs producing cocoons Per cent	Cocoons Number	Adults emerging Males Number	Females Number	Total Number	Cocoons producing adults Per cent
1931	Large second-instar	51.0	685	460	27	487	71.1
	Small second-instar	54.0	629	372	4	376	59.7
1933	Second-instar	44.0	152	114	3	117	77.0
	Third-instar	63.1	577	131	269	400	69.3
	From field during August	42.5	588	319	112	431	73.3
	From field after Aug. 31	49.7	736	186	270	456	61.9

Little difference is shown in the development of the parasite on second-instar grubs of different sizes, but in both cases there is a decided scarcity of females emerging from these cocoons.

There was a slight difference in the percentage of second-instar and third-instar grubs upon which cocoons were formed and also in the percentage of cocoons producing adults. The greatest difference, however, was in the sex of these adults, there being a preponderance of males from second-instar host grubs and of females from third-instar grubs. These observations indicate that the third-instar grub is better suited to the normal development of the parasite, and also that the parasite population will remain low in areas where there is a scarcity of third-instar host grubs. No doubt a scarcity of third-instar grubs was the primary,

if not the only, cause of the small number of adult parasites at Columbus and Ogontz in 1932.

SEX RATIO OF PARASITES REARED ON GRUBS PARASITIZED IN AUGUST.—An experiment was begun in 1932 in an attempt to determine the sex ratio in adults from host grubs parasitized in the field during August, the period in which *T. popilliavora* adults are present in the field. Host grubs were obtained from the field daily, except Sundays, beginning August 19 and ending October 4, when the last female parasite died, and were subjected to parasitization by females that had been placed with males for mating. The grubs in the field during August are largely in the second instar (Table 1); after August 31 there is a rapid increase in the number of third-instar grubs. In Table 2 it is shown that a predominance of males were produced on host grubs that were obtained in the field during August, but that females predominated in the case of host grubs that were collected after August 31. These observations indicate that normal progeny from grubs parasitized in the field in August by mated females would consist largely of males.

The emergence of adults from cocoons obtained from host grubs in the second instar and third instar indicates not only that the third-instar grubs are more suitable for the normal development of the parasite to adults, but also, that the sex of the adults is influenced by the instar of the host grubs or the amount of food available for larval development of the parasite, or that female parasites have the ability to regulate the sex of their progeny, which is determined by the instar or size of the host grub receiving the egg. Although these data are not sufficient to prove this point, the indications arouse curiosity.

SULPHUR FUMIGATION OF MUSHROOM HOUSES

By A. C. DAVIS,[1] *Assistant Entomologist, Bureau of Entomology* and H. D. YOUNG, *Associate Chemist, Bureau of Chemistry and Soils, U. S. Department of Agriculture, Washington, D. C.*

Sulphur is much used for the fumigation of mushroom houses for controlling insects, mites, and fungi, both before the beds are filled with compost, and while the compost is in the house going through the heating process referred to as reaching the "peak heat." Owing to incomplete burning and inefficient fumigating methods, sulphur has not given uniformly good results, and for this reason it has not been used as extensively as its cheapness and effectiveness warrant.

[1]Names arranged alphabetically.

The purpose of the present paper is to give the results of some experimentation with sulphur fumigation in mushroom houses.

In these experiments sulphur of two grades was burned in pans in the houses, and the concentrations of sulphur dioxide gas thus secured were compared with those obtained with a special apparatus constructed for burning sulphur on the outside and blowing the gas into the house.

COMPARISON OF THE TWO GRADES OF SULPHUR IN FUMIGATION.—Approximately 80 per cent of the sulphur sold for fumigation purposes in the mushroom-growing area of Pennsylvania is of the grade known as "commercial." This sulphur is light yellow in color, dense, and exhibits a tendency to become lumpy. It is much more difficult to ignite than flowers of sulphur and burns very slowly and incompletely. The maximum combustion of this grade secured experimentally when burned in pans was 14.0 per cent and the average was 11.6 per cent. The large quantities of unburned sulphur "slag" to be seen upon the refuse heaps of mushroom plants where commercial sulphur is used indicate that this is the usual experience. The concentrations attained by burning the commercial grade of sulphur in the houses were so low that they were of very little value in control of either insects or fungi.

Flowers of sulphur is deep yellow in color, less dense than the commercial grade, and does not have the same tendency to lumpiness. It is easy to ignite and burns better and more completely. The highest percentage burned experimentally in pans in the house was 95.0, and the average was 84.20. The average of the maximum concentrations of the whole series of tests made with this grade burned in pans within the houses was above 10 mg. per liter. In addition to the points already enumerated, this grade burns much faster than the commercial grade, giving a higher concentration in a shorter space of time. This is important in that many mushroom houses cannot be made gas tight, and the gas, if generated slowly, leaks out almost as fast as it is given off. Figure 44 gives the curves obtained experimentally in fumigating mushroom houses with sulphur. Each curve represents an average of two or more fumigations made with the designated grade and method. It will be seen that a much higher concentration is obtained with flowers of sulphur burned inside the house (Fig. 44, No. 3) than with the commercial grade burned in the same way (Fig. 44, No. 1).

With the outside burner there is less difference in the percentage of the two grades burned—96.7 per cent of the flowers against 62.5 of the commercial—but the concentrations secured with commercial sulphur are still rather low (Fig. 44, No. 2) while the concentrations se-

cured with flowers go well above 16 mg. per liter (Fig. 44, No. 4). The following table gives the figures for both burning and concentration of gas in the houses:

	Flowers of sulphur		Commercial sulphur	
	Burner	Pan	Burner	Pan
Average per cent burned	96.7	84.2	62.5	11.6
Average maximum concentration, mg. per liter	16.8	10.2	4.9	1.9

From the figures given above it seems that the flowers of sulphur is much to be preferred to the commercial grade for fumigation, especially

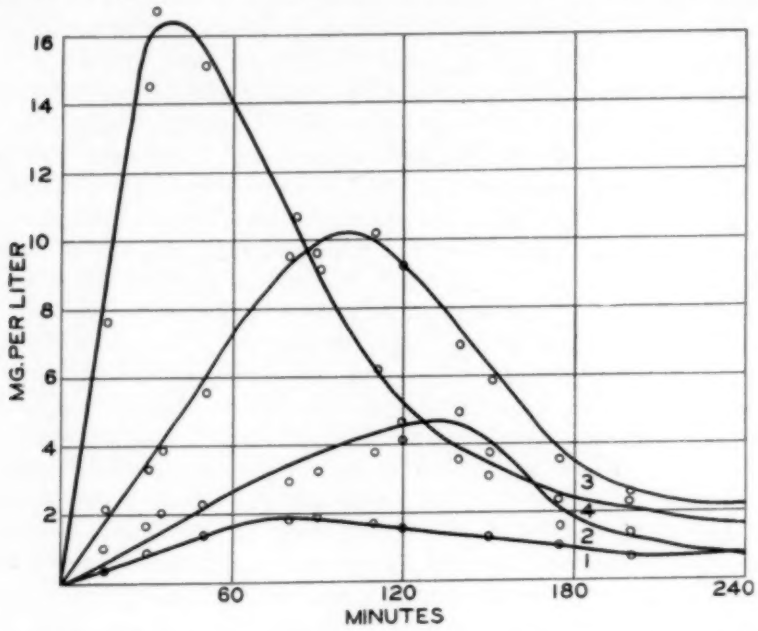


FIG. 44.—Curves showing concentrations secured in fumigating mushroom houses between fillings. Dosage of 2 pounds of sulphur per 1,000 cubic feet of air space. 1. Commercial sulphur burned in pans in the house; 2. Commercial sulphur burned in outside burner; 3. Flowers of sulphur burned in pans in the house; 4. Flowers of sulphur burned in outside burner.

if it is to be burned in pans within the houses. Commercial sulphur can be used in the burner, and, if a good burning is had, gives very fair results, but there is a high percentage of failures due to slow or incomplete combustion of the sulphur. Flowers of sulphur burns faster and more completely, and gives higher concentration of gas in the houses for any given quantity of sulphur used.

PREPARATION OF THE HOUSE FOR FUMIGATION.—Many growers probably do not realize the great importance of having the houses tightly closed during fumigation. All openings, including the doors and ventilators, and all cracks should be sealed with strips of paper and paste. Ordinary flour paste is very satisfactory for this purpose. If a house is very leaky the gas may escape almost as fast as it is generated, and never reach a concentration high enough to be of value. In an empty house fumigated experimentally at a dosage of 2 pounds per 1,000 cubic feet of air space with the ventilators and doors closed but not sealed, the average peak concentration of gas obtained with flowers of sulphur burned in pans in the house was slightly below 10 mg. per liter, whereas with the same material in the burner the concentration was slightly above this figure. For comparison, tests were run in the same house after the ventilators and doors had been sealed. In this case flowers of sulphur burned in pans within the house gave an average maximum concentration of about 12 mg. per liter, and the same sulphur in the burner gave 16.4 mg. per liter.

DISTRIBUTION OF GAS IN THE HOUSE.—*Method of determining distribution:* Samples of air were aspirated through glass tubing from various parts of the house through n/100 I_2 solution containing starch, using the Shelby method of determining SO_2. A standard mushroom house was used which contained approximately 16,000 cubic feet of space. It held six tiers of mushroom beds of the usual size. During the tests in which the sulphur was burned within the house frequent inspections were made to record the temperature, length of burning time, etc. When the burner was used observations were made to insure that no flames were being blown into the house.

Burning within the house: In burning sulphur within the house from 3 to 5 sheet iron pans are placed at equal intervals along the central alleyway. Some growers, however, prefer to construct a similar number of dirt basins on the floor of the mushroom house instead of using the pans. This gives good horizontal distribution of whatever concentration is secured. Under ordinary circumstances the air along the floor of an empty mushroom house may be from 4° to 8° F. cooler than that at the top of the house. As the thermometer is raised from the floor it registers higher until at about two thirds of the way it is very little lower than at the top. The heat from the burning sulphur, especially in the larger dosages customarily used (100 pounds per house, or over 6 pounds per 1,000 cubic feet of air space) for fumigating empty houses, will raise the temperature at the top of the house as much as 10° or 12° F., but will not, as a rule, very much affect the temperature of the air along the

floor level. The gas generating from the pans is very hot, and in spite of the fact that sulphur dioxide is about 2¼ times as heavy as air under similar conditions it tends to rise and to remain at the top of the house. Since electric fans cannot usually be used to keep the air in circulation during sulphur fumigation, the only movement is that of the gas rising vertically from the pans, and uniform distribution is obtained only after the sulphur has stopped burning and the temperature at the top of the house has lowered sufficiently to allow the gas to drop toward the floor of its own weight. By this time leakage and absorption have usually reduced the total concentration to a point too low to be of value. Thus, although the top and middle of the house receive a good fumigation, the bottom does not, and the insects and fungi surviving there will eventually reinfest the whole house. Average curves secured in fumigation of a mushroom house with a dosage of 2 pounds per 1,000 cubic feet of air space show that at the top and middle of the house the maximum concentrations reached were 12.6 and 12.0 mg. per liter, respectively, but that 1 inch from the floor the peak concentration was only 6 mg. per liter. There was 6° F. difference in temperature between the top and the bottom of the house to begin with. The relatively small amount of sulphur burned was not enough to raise the temperature at the top of the house more than a degree or so. The concentration at the top and middle of the house equalized within 30 minutes after the sulphur had finished burning and remained approximately uniform from then on. The temperature along the floor level was not raised at all. The dropping of the cooling gas from the upper part of the house caused the concentration along the floor to drop less rapidly than in other parts of the house, but by the time distribution of gas was uniform all through the house the concentration had dropped to about 2 mg. per liter, too low to be of value.

The outside burner: In fumigating with the outside burner the same difficulties are met with as when the other method is employed, but they are not so serious. A great deal of the heat of combustion is lost through radiation from the burner and from the lead-in pipe, so that the blast of gas, while warm, is usually cool enough so that the hand can be held in it. The initial uneven distribution of temperature within the house is broken up somewhat by the circulation of the blast of gas down the length of the house. Blowing the gas along the bottom of the house also displaces a large part of the cool air, and tends to warm this and to further cool the gas, preventing it from rising to the top of the house as fast as it otherwise might. The maximum concentration at the top of the house is still much higher than at the bottom, but it becomes uni-

form throughout the house much more quickly. Experiments in a house using 32 pounds (2 pounds per 1,000 cubic feet of air space) in the burner showed that the concentration at the top and middle of the house was usually the same, and above 15 mg. per liter, while the concentration 1 inch from the floor was usually above 12 mg. per liter. Distribution of the gas became uniform throughout the house within a few minutes time after the peak concentration had been reached, and before the concentration at the bottom had dropped more than ½ or 1 mg. per liter, and it remained uniform from then on.

Since the burner was placed at one end of the house the question arose as to whether or not the blast was strong enough to force the gas to the other end and give a uniform horizontal as well as vertical distribution. That it is capable of doing so was determined by placing the ends of the sampling tubes along the center walk of the house 8 feet from the floor, one 6 feet from either end of the house, and one in the middle of the house. Tests showed that the concentration of the gas from end to end of the house was remarkably uniform, with the same peak concentration, and practically no variation during the rise and fall. To test the possibility of dead air pockets further tests were made with the end of one of the sampling tubes 1 inch from the floor and 1 inch from either wall, in a corner of the house at the end farthest from the burner. The concentration of gas was found to be the same here as elsewhere near the bottom of the house.

The temperatures in mushroom houses during the time the manure is heating in the beds, immediately after the beds are filled, are very high, reaching 90° to 100° F. or more at the bottom and from 120° to 140° F. at the top. This uneven distribution of temperature is usually corrected to a great extent by running one or more fans in the house. These, however, must be taken out before fumigation with sulphur, the upper part of the house being allowed to again become hottest. Since the high temperatures are sustained by the fermenting manure, the heated gas rising to the top of the house will remain there for some time. The blast from the burner, in this case, acts partly as a substitute for a fan, breaking up the initial uneven distribution in temperature and causing a much more uniform distribution of gas.

In addition to the extremely high temperature in mushroom houses at peak heat, high humidity is also encountered and the manure is very moist. This excessive moisture tends to take the sulphur dioxide out of the air almost as fast as it is generated. Dosages of more than 2 pounds per 1,000 cubic feet of air space are not advisable, as the absorption of gas tends to increase the acidity of the bed surface too greatly. Ex-

periments have shown that with this dosage, even if rapidly generated in the outside burner, very low concentrations of gas result and the drop in concentration after the peak has been reached is so rapid that relatively short exposures to a lethal concentration result.

In many cases a green mold grows upon the surface of the beds following fumigation with sulphur. This usually disappears before casing and seems to be quite harmless, but many growers object to its presence.

EFFECT OF SULPHUR FUMIGATION UPON PESTS.—In the experiments in the mushroom houses the following species were used:

The springtail *Lepidocyrtus lanuginosus* (Gmel.), adults and larvae.

The mushroom mite, *Tyroglyphus lintneri* Osb., adults, larvae, and hypopi.

The mite *Histiostoma* sp., adults, larvae, and hypopi.

The mushroom fly *Sciara* sp., adults and larvae.

The mushroom fly *Megaselia iroquoiana* Malloch, adults.

Sciara larvae, *Histiostoma*, *Tyroglyphus*, and *Lepidocyrtus* were exposed in the house in small metal cans, the bottoms and tops of which were composed of fine wire screen. To prevent the insects and mites from drying out, small bits of moist spawn were placed in the cans with them. The cans containing the specimens were placed at each end of the house, usually 1 inch from the floor and 1½ feet from the false ceiling. The cans were examined about 4 hours after exposure and the relative numbers of living and dead insects noted. Adult flies of both species were sometimes confined in glass tubes 1 inch in diameter and 5 inches in length, the ends covered with coarse cheesecloth. Since flies of both species were present in numbers in the house on the windows 2 feet from the floor at the south end and 7 feet from the floor at the north end, paper was placed beneath these to catch the flies affected by the sulphur and the number of recoveries noted. Since the gas does not penetrate the beds deeply flies were found to emerge from within the beds and come to the windows after the concentration of gas had dropped below 1½ or 2 mg. per liter.

The springtails and adult flies of both species were the most easily killed, none having survived an exposure of 43 minutes to a concentration of over 4 mg. per liter, the concentration rising to 4.4 mg. per liter in this case. The kill of other pests used was found to be somewhat irregular, owing partially to the pests hiding within the moist spawn pieces into which the gas does not penetrate well, and perhaps partially to individual variation in susceptibility to the gas. In the experiments in the mushroom houses, 100 per cent kill of all insects and mites actually exposed to the gas resulted in all cases in which the con-

centration of gas reached 10 mg. per liter and remained above 4 mg. per liter for 87 minutes or more.

Mites, especially in the hypopal stage, were found to be the most difficult to kill, as they are able to hide within the spawn pieces very easily. The larvae of *Sciara* also sometimes survive in this way. In one case one adult and several hypopi of *Tyroglyphus* and one larva of *Sciara* thus survived an exposure which reached 12.5 mg. per liter and which remained above 4 mg. per liter for 105 minutes. In another case hypopi of *Tyroglyphus* and *Histiostoma* survived an exposure which reached 9 mg. per liter, and which remained above 4 mg. per liter for 119 minutes.

THE RELATIVE VALUE OF BORDEAUX MIXTURE, SULPHUR AND PYRETHRUM PRODUCTS IN REDUCING POPULATIONS OF THE POTATO LEAFHOPPER (*EMPOASCA FABAE* HARRIS)

By DWIGHT M. DELONG, *Columbus, Ohio*

For several seasons experimental work has been in progress in attempts to control the potato leafhopper (*Empoasca fabae* Harris) on beans and potatoes. During this time Bordeaux mixture, sulphur and pyrethrum products have been used rather extensively and many other materials have also been tested. The purpose of this discussion is to show the relative values of these three materials in the reduction of the leafhopper populations. The majority of the work has been carried on at Columbus, Ohio, on the University Farm. Several weeks were spent on the east coast of Florida in company with Dr. Neale F. Howard, making investigations of these materials in the truck crop section near Boynton for the U. S. Bureau of Entomology during the spring of 1933. The extremely heavy populations in that area gave an excellent opportunity for testing these materials under severe infestations.

METHODS USED FOR FIELD TOXICITY TESTS.—The method used for determining populations was to count the nymphs present upon 25 or 50 trifoliate leaves upon each plot, picking these leaves or an equal proportion upon the same relative level upon each plat but choosing the plants in any respective plot entirely at random. The nymphs in these counts were divided into two groups. The fourth and fifth instar nymphs were designated large, while the first, second and third instar nymphs were designated as small. Also the number just hatched was indicated, especially where the numbers upon spray plots had been greatly reduced or entirely killed by spray materials. Since the leaves

contain eggs which hatch over a period of a week or ten days after treatment, data concerning two problems can be obtained. First, the effect of any material upon the viability of eggs and, second, the "residual" or "carry-over" effect upon the young nymphs after hatching. For instance, if young nymphs which have just hatched are found when making counts on succeeding days but no larger nymphs are present, it is indicative of a carry-over effect or residual toxicity. This is verified where the young nymphs are found dead upon the leaves. The graphs are then constructed upon the basis of number of nymphs per 100 trifoliate leaves.

During the development of an individual nymph it will move about considerably upon a bean plant, especially moving upward, but nymphs very seldom leave the plant. On the other hand, the adults are very active and move from plant to plant and row to row very freely. Evidence shows furthermore they move freely from field to field. The count of the nymphs and the disregarding of adults is therefore considered the best index to relative populations. Furthermore, if the adults are present in different numbers, the egg deposition and subsequent hatching during the period under study will usually give a better indication than an attempt to count the shifting and active adults.

In the laying out of plots judgment should be used so far as possible to determine soil or moisture conditions, if variable, differences in plant growth conditions and variability in populations. By making population counts throughout the field and choosing plants at random in the various areas, the original populations can be determined on all plots and the checks can then be chosen wisely for every different or varying condition must be determined by a sufficient number of check plots.

Treatments were all made by applying sprays and dusts to the undersides of the leaves and so far as possible uniform conditions were chosen for all plots of a given series.

STUDIES WITH BORDEAUX MIXTURE.—Previous studies have indicated that Bordeaux mixture does not affect this insect directly by application to the insect's body. On the other hand applications of Bordeaux to the bean or potato plant causes the sap of the plant to become toxic to the insects and the sap remains this way for a period of a week or 10 days. The studies have also showed that the eggs which have already been placed in the plant tissue by the female hoppers before treatment are not affected, but that the nymphs are killed soon after they hatch and have fed on a plant that has been sprayed.

Field tests show that these populations are unable to build up on Bordeaux sprayed plots. (Fig. 45.) Even though large numbers of eggs

hatched daily on these plants, the nymphs were killed off as rapidly as they emerged from the eggs and the plants were consequently protected from feeding injury as long as the Bordeaux mixture spray was effective. For want of a better term we have called this a residual effect. Under Florida conditions Bordeaux mixture effectively controls this leafhopper, but on certain soils and under certain conditions Bordeaux

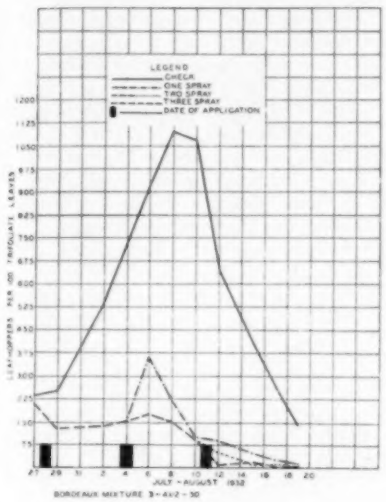


Fig. 45

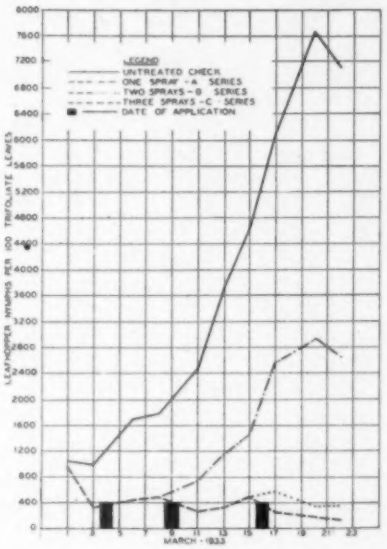


Fig. 46

mixture may cause injury to bean plants and should not therefore be unqualifiedly recommended. This injury is especially pronounced when applications are made during hot dry weather or in intense sunlight. Also where plants are growing in a soil thoroughly and continuously saturated with water so that the plant growth is vigorous, tender and succulent, Bordeaux mixture may cause serious injury to the leaves. The effective reduction of populations with Bordeaux under Florida conditions is shown in Fig. 46.

Contact Insecticides.—It has been customary to recommend and use contact insecticides for controlling insects which suck juices from plants. Of the more prominent contact insecticides three of them—nicotine, derris and white oil—have not given much promise against this leafhopper. One of the most prominent, pyrethrum, is very effective, but it kills only the insects touched by the material. It does not

have lasting or residual effect and it does not affect the eggs which are in the plant tissue. It does have the advantage of killing the adults present at the time of application as well as the nymphs. However, when it is used alone, either as a spray or as a dust, the control of the

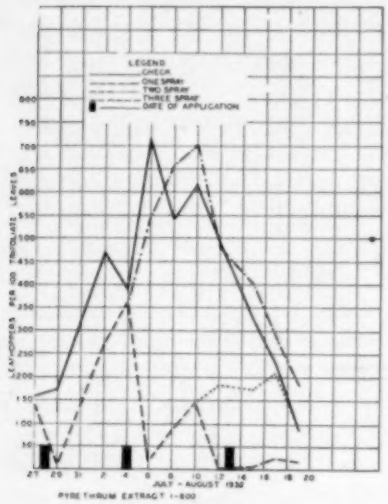


Fig. 47

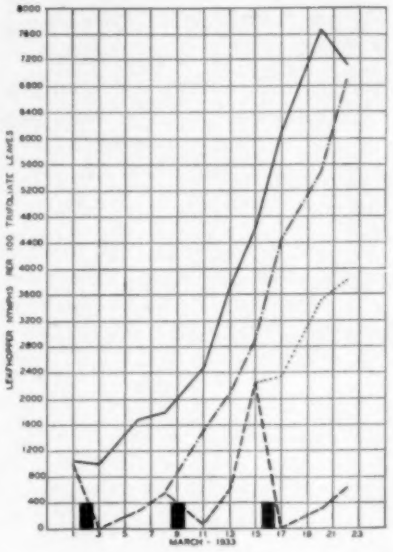


Fig. 48

insect is very difficult, for the hatching nymphs soon build up enormous populations upon the plant. Some of the recent dust materials seem to be more valuable than the sprays but even in this case it is necessary to use frequent and thorough applications. The population curve as affected by pyrethrum extract spray is shown in Fig. 47, and a similar effect under Florida conditions in Fig. 48. Note how rapidly the populations increase after the active nymphs are reduced to almost zero.

The effect of the pyrethrum dust materials are shown in Figure 49. All of these pyrethrum dust plots showed a lack of residual effect or control.

During these experiments various types of sulphur products were used and in general these sulphur materials show a similar residual effect as in the case of Bordeaux. The exact effect of sulphur upon the insect or the plant or both and the method of its action are not known. In most cases the toxicity of sulphur to insects has been attributed to volatile products, but the residual effect could scarcely be correlated with a

volatile product, especially when the effectiveness may last for a period of several days. The plant also shows an unusually healthy and vigorous condition when treated with certain sulphur materials which may be due to its freedom from insect and fungus pests or may be due to

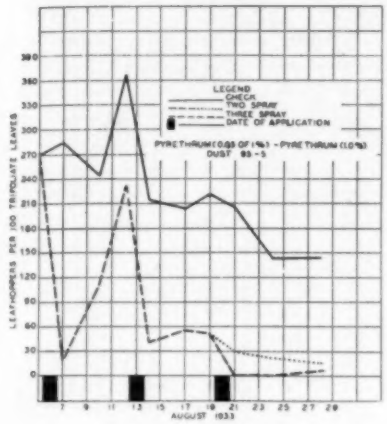


Fig. 49

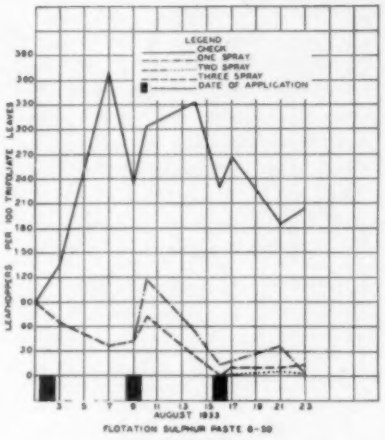


Fig. 50

some stimulative action upon the plant. Sulphur treated plots are usually free from the stunting and curling action characteristic of leafhopper injury.

Where detailed experiments were carried out to determine the general effect of the sulphur on leafhoppers it was found that when the plant was treated and leafhoppers placed on the leaves a week, two weeks or even three weeks later in some series of tests, these insects would die in 4 or 5 days after being placed on these plants.

If these sulphur spray materials were put in shallow containers and placed under the leaves where the leafhoppers were feeding and a bell jar placed tightly over the small plant, the volatile product did not produce toxic effects upon the feeding insects. No toxicity was produced even when these were used in concentrated solutions.

In general the results obtained on the plats treated with sulphur were similar to those obtained on plats treated with Bordeaux mixture. In some cases reduction of the population was comparable to the reduction with Bordeaux and in some the reduction was not so great, depending on the type of sulphur used. As a spray, flotation sulphur paste has given excellent results in proportions of 8 lbs. to 50 gallons. The initial reduction of the populations was not so great, but the residual value was

comparable to Bordeaux mixture. This is shown in Fig. 50. Also wettable dry sulphur 5 lbs. to 50 gallons and dry mix spray 12½ pounds to 50 gallons gave excellent reductions in the populations, (Figs. 51, and 52). It is apparent that volatile products are not important in these sulphur sprays in general as the two containing the most volatile products—

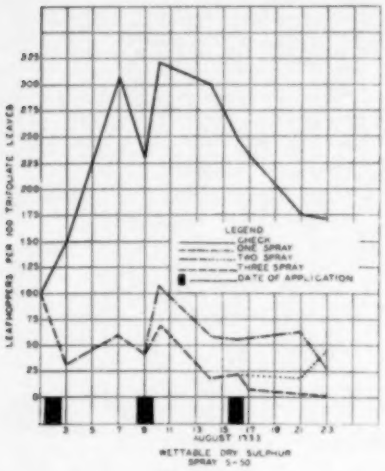


Fig. 51

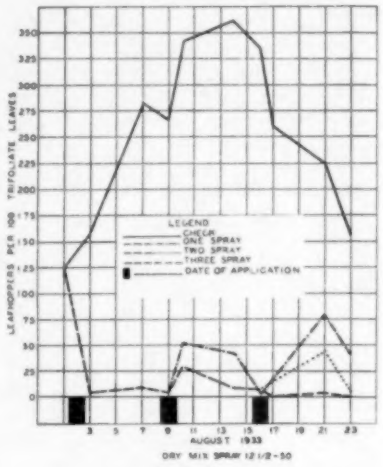


Fig. 52

colloidal sulphur containing H_2S and liquid lime sulphur containing SO_2—gave good reductions at the time of spraying but showed comparatively little residual control or value and as a consequence the populations again increased rapidly soon after application.

In some areas and under certain farming or cropping conditions, it is necessary or advisable to use dust materials instead of spraying. The growers in many areas, therefore, prefer this type of application. A large series of dust materials have been used and results indicate that finely ground sulphur (300 inch mesh) is probably as good as an insecticide and as easy to apply as any of the sulphur products. The effect of sulphur dust alone is shown in Figures 53 and 54. Although the reduction of population is much slower, the residual value is excellent after the population is reduced.

In cases where it has seemed advisable to use dusts in place of sprays for field applications, the combinations of sulphur and pyrethrum dusts have given the greatest protection of the plants. This is probably due to the fact that a small amount of pyrethrum dust will reduce the population immediately to about zero and the sulphur acting as a residual

material prevents the building up of these populations by killing the newly hatched nymphs for a period of a week or 10 days afterwards under field conditions.

Under Ohio conditions sulphur and pyrethrum dusts have been combined with excellent results in reducing leafhopper populations both

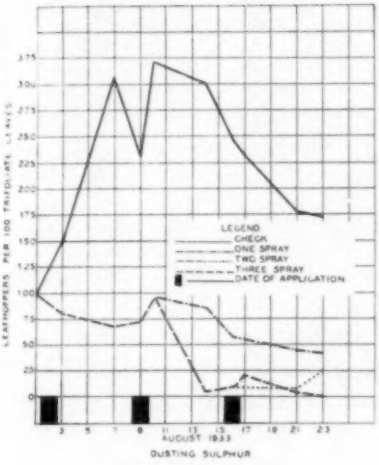


Fig. 53

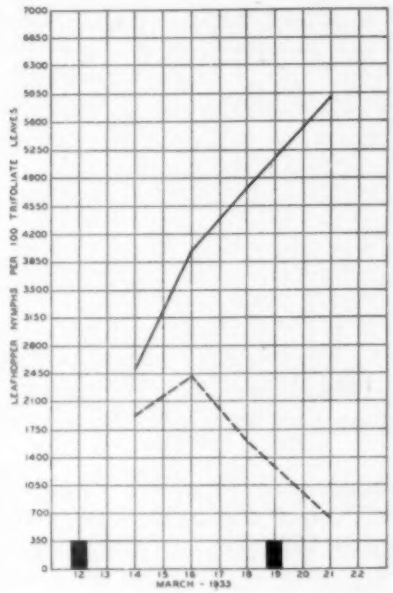


Fig. 54

immediately and over a period of several days. Pyrethrum dusts are manufactured so as to contain different percentages of pyrethrins. The most common and available type, that product known as pyrethrum flowers, contains approximately 1 per cent of pyrethrins. This has been combined in varying proportions but satisfactory results have been obtained when sulphur and pyrethrum was combined 95 to 5 and 90 to 10, which combinations gave pyrethrin contents of 0.05 and 0.1 of 1 per cent respectively. The reduction of the population with a 95–5 combination is shown in Figure 55. In view of the fine inert material in the pyrethrin dust, the physical properties of the dusting mixture are improved as well as the added insecticidal value. Other pyrethrum dusts contain as low as 0.05 of 1 per cent pyrethrin content. This contains a large amount of residual material and further improves the physical qualities of the mixture. In proportions of 50 to 50 sulphur and py-

rethrum, there is not sufficient sulphur present to give the necessary residual value, but when this is used in proportions of 75 to 25 in which case the actual pyrethrin content is reduced to 0.0125 of 1 per cent, there are sufficient pyrethrins to effect an immediate reduction in the population and the sulphur content is increased sufficiently to give a high residual value. This is the cheapest form in which sulphur and py-

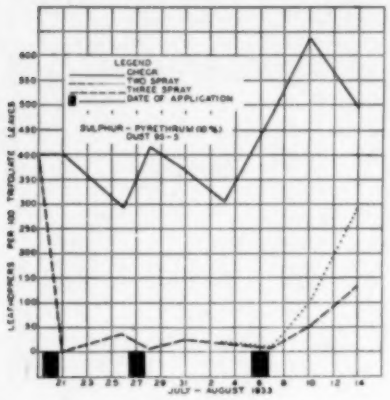


Fig. 55

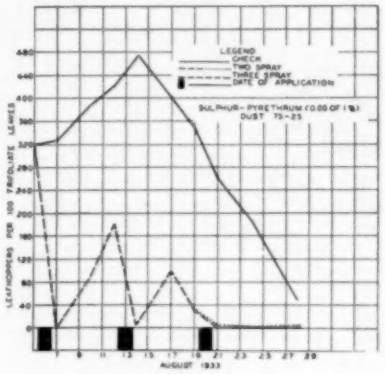


Fig. 56

rethrum can be obtained and it is the safest and most efficient combination which has thus far been used. Equally good results were obtained with some of the other combinations of sulphur and pyrethrum dusts. When the grade of pyrethrum dust was used which contained only 0.5 of 1 per cent pyrethrins, the physical properties were improved and at the same time a considerable pyrethrin content was added. In some cases such combinations gave better toxicity results and better reductions of populations than mixtures where less pyrethrum dust was added, but the pyrethrin content of which was greater. This indicates that to some extent, when combined with sulphur dust, the physical character of the pyrethrum dust may be as important as the chemical, providing a small pyrethrin content is present.

Sulphur dust alone will give a practical and economic control but it will be necessary to use more applications and begin somewhat earlier in respect to the life of the plant. This is necessary because the populations are not reduced as rapidly after they have become large as when pyrethrum is combined with it, but they can be prevented from becoming large if applications are made early. Sulphur dust will also control red spider on beans very effectively while Bordeaux mixture or pyrethrum alone are not effective control measures.

Dust materials containing sulphur should be applied at the rate of at least 30 pounds per acre. Unless the dusting qualities are greatly improved it may be necessary to use more than this specified amount.

The dusting qualities of flotation sulphur are excellent. When used in combination with pyrethrum dusts, the toxicity factor for immediate reduction of populations was as pronounced as in the combinations with dusting sulphur but the residual value was greatly reduced as compared with that of dusting sulphur. As mentioned above, however, in the spray form, flotation sulphur gave a high residual value.

By making population counts day after day on field plots where various materials are being used, a better knowledge can be gained concerning the relative value, relative toxicity or residual effect of insecticidal materials than in any other way and a better field picture can be obtained as shown in the accompanying graphs.

Summary

1. Bordeaux mixture is effective in reducing leafhopper population by producing a plant condition that might be termed a residual effect so that the hatching leafhoppers die over a period of several days after application. Under specific conditions however Bordeaux may cause injury to bean plants.

2. Of the contact insecticides, pyrethrum is the only one which has given any promise and this one is of value only in reducing immediate populations. It is highly toxic to leafhoppers but has no residual value so populations of hatching nymphs build up very rapidly in case of spray or dust applications.

3. As a substitute spray flotation sulphur paste 8 to 50, wettable dry sulphur 5 to 50 and dry mix spray 12½ to 50 have given excellent results. Sulphurs show a residual effect similar to Bordeaux mixture.

4. In areas where dusting is most practical or dusts are desired, dusting sulphur, 300 inch mesh, combined with 5 to 10 per cent of pyrethrum dust has given excellent results. The pyrethrum dust in small quantity gives a toxic value for immediate reduction and the sulphur gives a residual value which prevents the rebuilding of the population when reduced. This is probably the safest and most economical form in which sulphur can be used.

5. Sulphur products have the further value of being important in controlling other pests on bean. Red spider has been controlled effectively and there is indication that they may be of at least some value in protecting plants against bean beetle. Bordeaux mixture is of practically no value against either of these pests.

FLIGHT STUDIES OF *BRUCHUS PISORUM* L. (COLEOPTERA, BRUCHIDAE[1]

By CLAUDE WAKELAND, *Department of Entomology, University of Idaho*

The pea weevil, *Bruchus pisorum* L., causes greater or less injury every year within an area known as the Palouse Region of northern Idaho and eastern Washington. The importance of peas as a crop and the loss caused by *Bruchus pisorum* L. are fairly accurately expressed in the records of commercial seed concerns serving the territory, a summary of which appears in Table 1.

TABLE 1. PEA ACREAGE AND PERCENTAGE OF INJURY FROM THE PEA WEEVIL FOR THE TEN-YEAR PERIOD 1923–1932 INC.

Year	Acreage	Per cent of injury
1923	30,000	6
1924	30,000	8
1925	25,000	12
1926	25,000	18
1927	40,000	20
1928	45,000	8
1929	60,000	5
1930	70,000	8
1931	65,000	10
1932	60,000	12
1933	66,000	4.1*

*Record of the Agronomy Department, University of Idaho. Determined from all samples examined in inspecting peas for Federal Grades.

Studies of the pea weevil in the area mentioned have proven that a large proportion of the beetles which mature in any season emerge from peas in the autumn and then go into hibernation in favorable places until the following spring. It has been reported that some of them hibernate in trash in the field or fence rows, in cracks and beneath splinters of bark of fence posts, etc., (Whitehead, 1930), and that some fly to forested areas more or less remote from pea fields (Larson and Hinman, 1931).

The Idaho Agricultural Experiment Station began investigations of the pea weevil in northern Idaho in 1926 (Whitehead, 1930). In the spring of 1930 the writer discovered that many weevils hibernate under the bark of ponderosa pine trees. Studies, in 1930, 1931 and 1932, were conducted to ascertain the direction, height, distance, time and duration of flight of *Bruchus pisorum* L. The writer had observed that weevils drop and remain motionless for a time after flying into an obstruction. This observation suggested the design and construction of

[1]Published with the approval of the Director as research paper No. 117 of the Idaho Agricultural Experiment Station.

the flight traps used in the three-year study. An attempt was made to have the traps serve as obstructions to the natural flight only. With this in view, sixteen-mesh galvanized iron screen was used as the obstructing material so that resistance to air currents would be at a minimum. The supporting frame was made of white pine lumber. The traps had a solid framework only 2¾ inches wide surrounding a screen area 19½ inches wide and 31½ inches high. A side screen and top projected out-

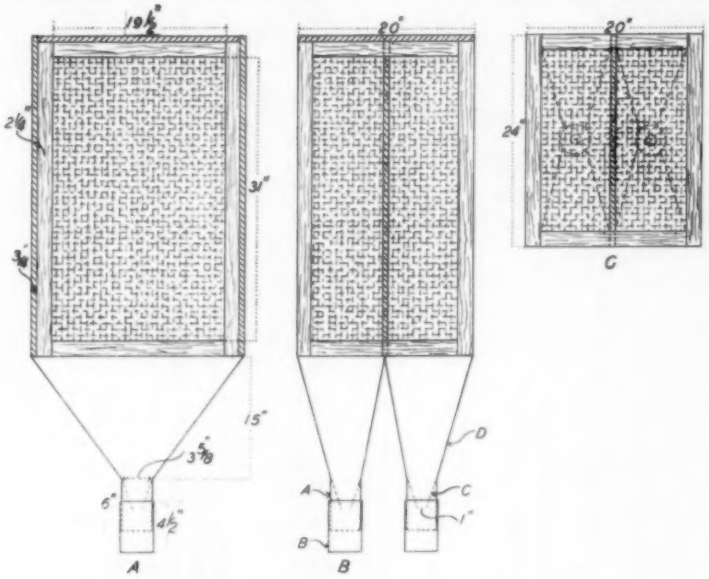


FIG. 57.—Detail of construction of flight traps. A, front view; B, side view showing center panel; C, top view, showing center panel.

ward 10 inches, serving to prevent weevils from flying around the center panel. A rectangular funnel (D, Fig. 57) was fastened to the bottom of the center panel. This was 10 inches wide, 26 inches long, and sloped toward the bottom where it was attached to a circular funnel (C) of dimensions shown in the diagram. Insects striking the center panel dropped into the rectangular funnel, then through the opening of the smaller funnel into a No. 2 "tin" can (B), which slipped tightly over a metal cylinder (A) surrounding the small cone of the funnel illustrated in Figure 57. Weevils crawl with extreme difficulty over vertical surfaces of smooth metal and very few of them were able to make their way up the sides of the can and the metal cylinder and then downward, to escape through the small opening of the funnel. Each trap was made

in two sections with openings facing in opposite directions, to permit obtaining information of the direction of flight in each location.

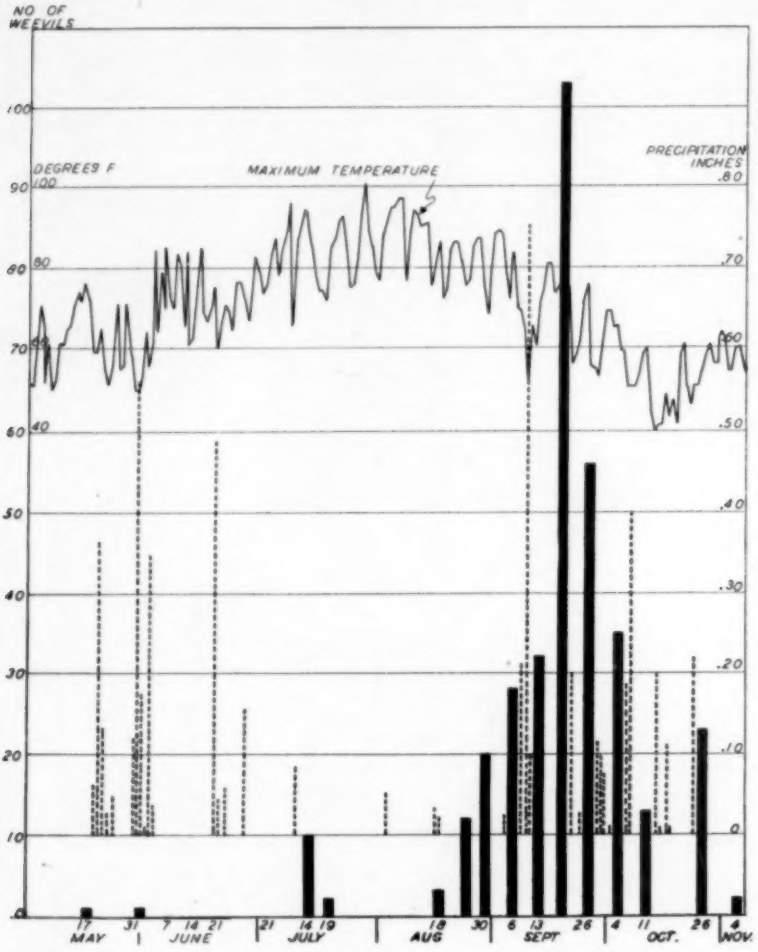


FIG. 58.—Record of pea weevils captured in flight traps, 1930. Daily precipitation is indicated by vertical broken lines.

Traps were placed in several fields and in locations at greater or less distance from cultivated areas and at heights varying from six inches to 70 feet above the ground. They were erected in 1931 and 1932 on high knolls, spaced as nearly as one mile apart and located as close to a base line as the physiography of the land permitted. The base line was ap-

proximately five miles long and extended in a northeasterly and southwesterly direction from the heart of the pea-growing area to the edge

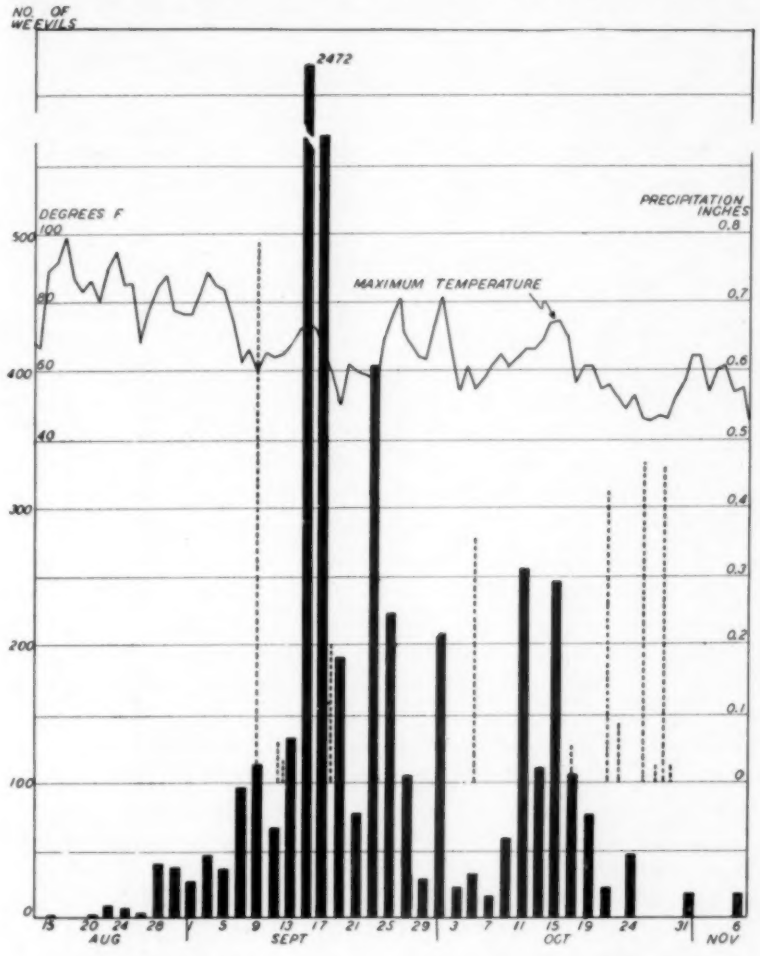


FIG. 59.—Record of pea weevils captured in flight traps, 1931.

of the forested area at the base of Moscow Mountain. Traps were examined at weekly intervals during the first year and each alternate day during the two succeeding years with the exception of two traps located on mountain tops which were examined only as opportunity afforded.

The beginning and duration of flight and the time of maximum flight may be visualized by examination of Figures 58, 59 and 60. In the three

years, 7529 weevils were captured in 27 traps. In 1931 and 1932, when traps were orientated with respect to the base line as already mentioned, 4212 weevils were captured on the side toward the forested

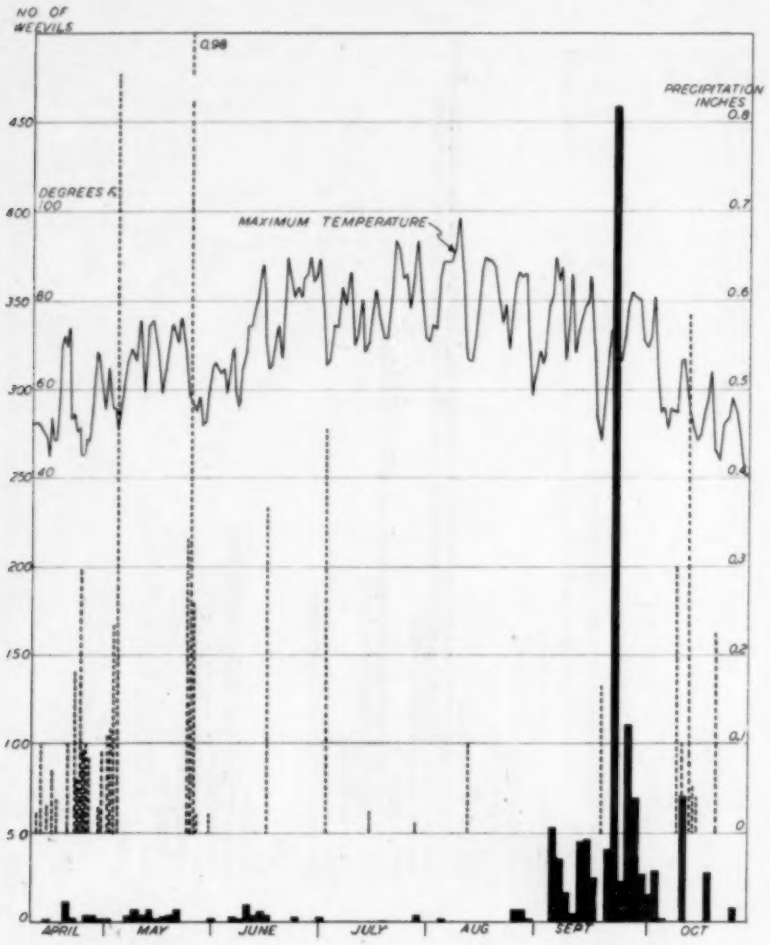


FIG. 60.—Record of pea weevils captured in flight traps, 1932.

area, while 2976 were captured on the side away from the forested area. Eight traps were operated in 1930, 10 traps in 1931 and nine traps in 1932.

The greatest numbers of weevils naturally were collected in flight traps erected in pea fields. Many other species of insects also were

captured as noted by Rice (1933). The chief facts gleaned from the mass of data are briefly presented here. Autumn flight of *Bruchus pisorum* L. begins shortly after the date when the first adults start to emerge from peas in the field and continues for a period of approximately two and one-half months; the dates on which the greatest number of weevils are in flight in the autumn is dependent on the occurrence of autumn rains following the usual drought of July and August. This is explained by the fact that the mature pea pods crack open soon after they dry out again following the first fall rains, allowing the escape of autumn-emerging weevils.

Weevils were captured in greatest numbers near the surface of the ground but many of them fly at least 70 feet high in cultivated areas and at least 50 feet above the ground at the edge of the forested areas a mile distant from pea fields. Large numbers of weevils leave the fields in the autumn and fly into timbered areas. Illustrating this fact, 207 weevils were captured in one trap (Fig. 61) 30 feet above the ground in such a location in the autumn of 1931. Assuming that they flew into the timbered area all along the margin of the cultivated fields in this district as they did at the location of the trap mentioned, in a band of air 31½ inches wide at an elevation of approximately 30 feet above the ground, they would have entered the forest at the rate of 5,588,842 per linear mile. Obviously, a great many more entered the forest higher or lower in the air than at the thirty-foot level.

Trap records did not indicate that there was a definite direction of flight with respect to either location or to prevailing wind, for, although 58.6 per cent of the total weevils were captured in traps facing away from the prevailing wind and toward the forested area, the proportions were reversed in many of the individual traps. Trap records indicated that there is a relatively small percentage of spring flight and that a relatively small percentage of the weevils entering the forested areas in the autumn fly back toward the cultivated fields in the spring.

The buttes and mountains in the eastern portion of the Palouse Region were originally forested and many forested areas still remain contiguous to or not far distant from cultivated fields. The dominant tree species is *Pinus ponderosa* Lawson, associated with which are *Pseudotsuga taxifolia* (La Lamarck) Britton and *Larix occidentalis* Nuttall. Numerous deep cracks extend radially from the surface toward the center of the tree in the bark of *Pinus ponderosa*. These extend tangentially in all directions, frequently anastomosing. From the sides of these cracks others extend under the bark scales more or less parallel to the perimeter of the tree and deeply beneath the surface. As the bark

becomes older, large patches are lifted up from these cracks and may remain affixed for years. The bark of *Pseudotsuga taxifolia* and *Larix occidentalis* is very much more closely appressed than that of *Pinus*

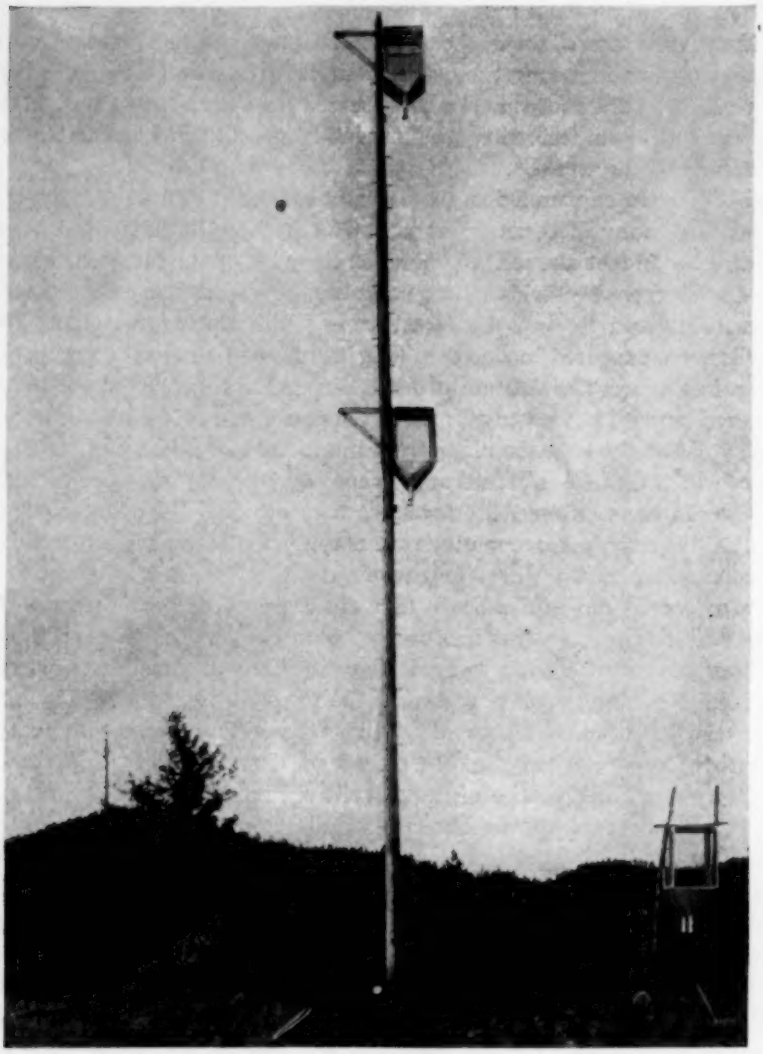


FIG. 61.—Flight traps in position adjacent to forested area and one mile distant from pea fields. The three traps shown are 50 feet, 30 feet and 8 feet above the soil surface.

ponderosa, thinner, harder, and is almost lacking in deep cracks. One cannot pry off large patches of the bark of these trees and the small bits that can be removed with a suitable tool are gouged out of the more or less homogeneous bark mass.

The fact that timbered areas afford very favorable hibernating quarters for the pea weevil has an important bearing on the survival of the species. From examinations under the bark of *Pinus ponderosa* Lawson during the normal hibernating period of the insect, it is significant to note that living weevils were excavated from trees in every location near pea fields. Furthermore, living weevils were found under the bark of the same species at distances from approximately one-fourth mile to three miles from pea fields during one or more of the years that studies were made. Korab (1927) has already reported *Bruchus pisorum* as flying two miles. Some of the trees examined were solitary outposts of forested areas. It is not strange that weevils made their way to them for no obstructions were offered to flight; neither was it necessary for them to attain any considerable elevation in their flight. Several of the locations, however, were interior from the margin of the forest and, to reach them, weevils had to fly over high trees or between trees and alight well within the forested area.

The type of examination necessary to expose weevils hibernating under the bark is so tedious that no great amount of bark can be examined in any reasonable length of time. One may safely infer, however, that where so many weevils are detected in such a comparatively small amount of bark area and in such a comparatively short time that they are just as likely to occur throughout the timbered area between the outer margin and the furthest innermost points where they were found. Indeed it is possible that they reach greater depths. It seems reasonable to conclude from the evidence that the forested area all around the base of Moscow Mountain, as well as on other timbered elevations, affords a hibernating zone at least two or three miles in horizontal and 835 feet in vertical width.

Another fact disclosed by examination of the bark of pine trees is that weevils appear to be limited in the height at which they hibernate on the trees only by the character of the bark. They were observed in decreasing numbers from the base of the tree to a height of 40 feet where the bark became so smooth and tightly appressed as to afford little opportunity for them to find protection.

Variation in the character of the bark within small distances on an individual tree and between trees growing closely together are too great for this type of datum to yield significant information concerning the

proportion of hibernants or the extent of the population from year to year. However, in a general way, the relative abundance of weevils and the expectancy of high or low field populations may be obtained each year insofar as timbered areas are a contributing factor. Attention is directed to an example of this in one location where an examination lasting 90 minutes failed, in the spring of 1930, to expose any weevils but where they were exposed in the autumn of that year at the rate of 270 in the same unit of time. Unfortunately, data at this location in the spring of 1931 were secured on an area basis but it was evident, from the fact that 16 living and no dead weevils were exposed beneath 216 square inches of bark, that a high population survived the winter. In the autumn of the same year, 58 weevils were excavated from beneath the bark at the same location in 30 minutes, while 27 were secured in the same length of time in the spring of 1932.

Examination of the bark at stated intervals during the autumn and spring produced information as to approximately when the first newly emerged adults reached hibernating quarters in the autumn and when the last hibernants left the trees in the spring. In 1930 the last hibernants observed left the bark about June 12 and the first migrants of the new generation reached hibernating quarters under the bark between August 29 and September 4. In 1931, fall migrants reached the trees between August 26 and September 1. An indication that a small percentage of adults might hibernate for more than one winter was found in the fact that in 1932 hibernants from the winter of 1931–1932 were still under the bark August 22 in one location, when individuals of the new generation began to reach the tree.

Literature Cited

1. Larson, A. O., and F. H. Hinman.—The Pea Weevil Problem. Jour. Econ. Ent., 1930. 23: 398–401, 7 refs.
2. Korab, I. I.—The Pea and Bean Weevil. Bull. Belaya-Cerkov Plant Breed. Sta. 2 (4): 81–126, 7 figs., 27 refs.
3. Rice, Paul L.—Insects Collected in Flight Traps in the Vicinity of Moscow, 1933. Idaho. Jour. Econ. Ent., 26: 1079–1083.
4. Whitehead, F. E.—The Pea Weevil Problem. Jour. Econ. Ent., 23: 398–401, 1930. 7 refs.

THE RELATIONSHIP OF FINENESS OF SULFUR PARTICLES TO EFFECTIVENESS AGAINST THE CITRUS THRIPS IN CENTRAL CALIFORNIA

By E. A. McGREGOR, *Bureau of Entomology, U. S. Department of Agriculture*

Certain workers in the field of plant pathology have observed that fungus organisms exhibit varying degrees of susceptibility to fungicidal dusts, depending to quite an extent on the fineness of division of the dust particles. In a letter dated May 1, 1924, Prof. H. W. Fitch of the Department of Plant Pathology, Cornell University, stated: "Fineness of division appears to be a very important factor in determining the efficiency of a sulfur dust. Finely divided sulfur is more readily oxidized at ordinary temperatures than the ordinary sublimed sulfurs." Prof. Fitch reported on results in an orchard where sulfurs of different finenesses were tested for control of apple scab, as follows:

	percentage of fruit scabby
No treatment	100.0
100-mesh sulfur	49.0
200-mesh sulfur	13.0

Prof. R. E. Stephenson (*5*), of the Oregon Agricultural Experiment Station, states: "The more finely sulfur is ground, the more rapidly it is oxidized."

Streeter and Rankin (*6*) stated in 1930 that their data indicated that sulfur particles larger than 27 microns fail to adhere to the foliage of fruit trees.

R. P. Tucker, of the California State Department of Agriculture, states, in correspondence: "I think it is justifiable to say that where extra good coverage is required, all of the particles should be less than 35 microns. That is, all of the sulfur should pass a 325-mesh screen."

The present writer has employed various types and brands of sulfur against several crop pests, including the cotton red spider (*Tetranychus bimaculatus* Harvey) (*1*), the tarnished bug (*Lygus elisus* Van D.) (*2*), the citricola scale (*Coccus pseudomagnoliarum* Kuwana) (*3*), and the citrus thrips (*Scirtothrips citri* Moult.) (*4*). As these studies advanced, the writer became increasingly impressed with the importance of the factor of fineness, but was unable to find in the literature any reference to the specific subject of a correlation between the relative fineness of the sulfur particle and insecticidal efficiency.

For the purpose of conducting tests of such a possible correlation, an experiment was arranged in a 16-acre orchard of navel orange trees, near Lindsay, for the control of the citrus thrips. The tree and soil

conditions throughout the experimental acreage were as nearly uniform as one might reasonably desire. Quantities of three distinct "grinds" of sulfur were specially prepared by a certain manufacturer of dusting sulfurs. Fineness was the only variable—all other specifications being identical for these three sulfur dusts. Each sulfur was made free-flowing by the addition of about 1 per cent of magnesium carbonate.

The plats in the experimental orchard were of ample size, each containing 8 rows of 30 trees to a row, and each embracing about 2½ acres. Each type of sulfur was used on two plats, making altogether six sulfured plats. Each plat was dusted three times with intervals of about 4 weeks, and in the case of each of the three applications the

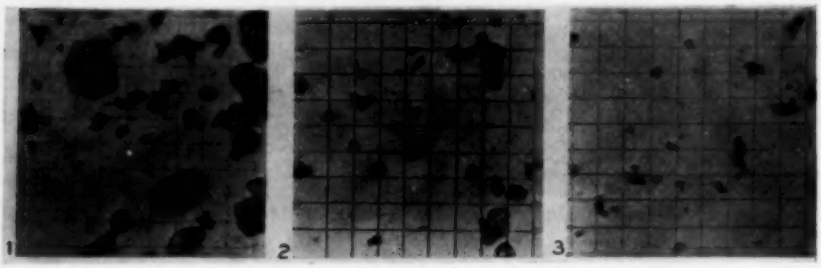


Fig. 62.—Photomicrographs of the sulfurs used in the Chapman orchard experiments. 1, The so-called "200-mesh" sulfur. 2, The so-called "325-mesh" sulfur. 3, The so-called "400-mesh" sulfur. All photographs represent enlargements of 140 times the actual size of the particles. A large square is 25 microns on a side.

entire experimental area was treated within a period of 2 hours. Thus the time element could hardly have been a variable factor. The sulfur was applied by a powerful motor-driven outfit, equipped with the modern fish-tail delivery tube. The same crew operated the duster at all times. Care was taken to adjust carefully the sulfur feed control so that the sulfur dosages were identical for each of the three sulfur "grinds". Thus the human element was practically eliminated. Untreated check plats of fair size were left at opposite corners of the orchard.

In Figure 62 photomicrographs are shown of samples of the three "grinds" of sulfur that were used in the experiments reported herein. The magnification is the same in all cases. Note that no particles in "2" are as large as the largest particles in "1", and that no particles in "3" are as large as the largest particles in "2". The very large sulfur particles, as in "1", are equivalent in weight to a great number of the smaller particles, as in "3". Furthermore, it is the belief among workers

who have studied sulfur dusts that the fuming efficiency of large particles is very low as compared with that of the same weight of sulfur in a more finely divided form.

At harvest time the trees were stripped of oranges, and counts were made of fruits sufficiently thrips-damaged to lower the grade below the top ("Fancy") grade. These counts and gradings were all made by the writer, who had gained nine years' experience in this specific operation. The data from the studies described above are given in Table 1.

TABLE 1. RESULTS OF STUDIES OF SULFUR FINENESS AND RELATED EFFECTIVENESS AGAINST CITRUS THRIPS IN THE CHAPMAN ORCHARD, LINDSAY, CALIF., 1932

Per cent (by weight) of sulfur passing 325-mesh screen	Total number of fruits counted		Number of fruits thrips-damaged		Per cent of fruit thrips-damaged			Average reduction in damage
	Replicate I	Replicate II	Replicate I	Replicate II	Rpelicate I	Replicate II	Average* for replicates	
65.0	1,600	2,900	297	349	18.6	12.0	15.3	74.2
90.1	3,000	2,300	337	188	11.2	8.2	9.7	83.6
95.8	3,600	900	194	29	5.4	3.2	4.3	92.7
Check	1,400	900	965	447	68.9	49.7	59.3	—

*A simple, not a weighted average.

When the data contained in the first and last columns of Table 1 (sulfur fineness and reduction in thrips damage) are plotted graphically, an interesting "curve" results. (See figure 63).

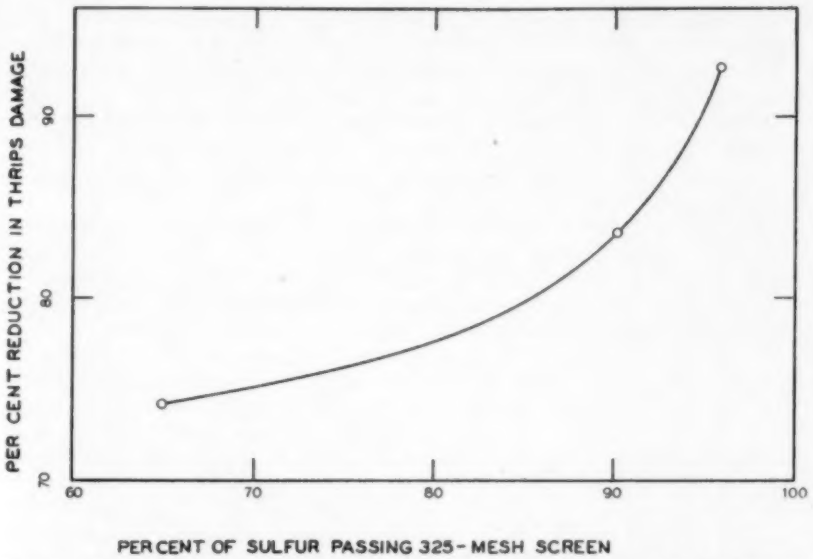


Fig. 63.—Chart showing correlation between the fineness of sulfur and its effectiveness against the citrus thrips in experiments in the Chapman orchard, 1933.

When the data on thrips damage were charted, it was seen that each plat in the north half of the orchard suffered somewhat more severely than the corresponding replicated plat in the south half of the orchard. However, the scarring of fruit in the two check plats would seem to indicate that this disparity is explainable through the population heterogeneity that probably existed in the orchard at the beginning of the experiment. It will be noted that the three distinct sulfurs exhibited the same relative effectiveness in both halves of the experimental acreage.

The data from the experiments in the Chapman orchard would seem to justify the conclusion that there appears to be a well pronounced correlation between the fineness of sulfur particles and the resulting effectiveness against the citrus thrips.

The writer makes no attempt here to interpret the fundamental cause of greater insecticidal effectiveness from increased sulfur fineness. Whether the actual rate of sublimation (fuming) is related to sulfur fineness was not necessarily established by the present studies. Fineness of division of dusts contributes materially to the adhesion and final distribution of the dust on the foliage, and these factors doubtless have a strong bearing on insecticidal efficiency.

Literature Cited

1. McGregor, E. A. The Red Spider on Cotton. U. S. Dept. Agr. Bul. No. 416, 72 pp., illus. 1917.
2. ————. Lygus Elisus: A Pest of the Cotton Regions in Arizona and California. U. S. Dept. Agr. Tech. Bul. No. 4, 14 pp., illus. 1927.
3. ————. An Innovation in Scale Control. Science 71 : 244–245. February 1930.
4. ————. The Thrips Situation in Southern California. The California Citrograph 18 : 128, 160, illus. 1933.
5. Stephenson, R. E. Relation of Fineness of Grinding to Rate of Sulfur Oxidation in Soils. Soil Science 21 : 489–494. 1926.
6. Streeter, L. R., and Rankin, W. H. The Fineness of Ground Sulfur for Dusting and Spraying. . N. Y. (Geneva) Agr. Expt. Sta., Tech. Bul. No. 160, 16 pp., illus. April 1930.

Scientific Notes

***Myelois venipars* Attacking Apple in Oklahoma.** Several larvae about ¾ inch long, creamy white in color, were found in apples on a Jention tree in the college orchard at Stillwater, Oklahoma, December 15, 1933. They were placed in rearing jars where they spun a thin silken cocoon and pupated in a few days at room temperature.

The adult moths emerged January 1 to 3, 1934, and were determined by Mr. Carl Heinrich of the Bureau of Entomology as *Myelois venipars* Dyar, known as the Navel Orange Worm.

This insect has been reported from Arizona and California as attacking oranges and lemons.

Later collections made January 15–16, 1934 produced moths February 2, 3, 6, 7, 1934. During this period the outside temperature has been to a minimum of 14 degrees F. and there is no indication of the larvae having been killed.

The larvae remain in their cocoons in the apple fruit as long as they are outside, but as soon as they are brought into the warmer air, they soon pupate. This indicates that they pass the winter, if they are able to survive, as larva.

Their attack of apples seems to have followed codling moth injury.

EPHRIAM HIXSON, *Assistant Entomologist, Stillwater, Oklahoma*

Host Plants of the Potato Psyllid. Greenhouse and laboratory rearing tests, using a large number of plant species, showed that the potato psyllid, *Paratrioza cockerelli* (Sulc), will oviposit, complete its nymphal development, and emerge as a normal adult upon the following plants, the majority of which are members of the family Solanaceae: *Atropa belladona, Convolvulus arvensis, Datura fatuosa, D. innoxia, D. metel, D. meteloides, D. stramonium, Hyoscyamus albus, H. niger, Lycopersicon pimpinelli-folium, Lycium halimifolium, Micromeria chammissonis, Nicandra physalloides, Nictina glutinosa, N. tabacum, N. texana, Physalis angulate, P. franchetti, P. heterophylla, P. peruviana, P. pubescens, Physalodes physalodes, Salpiglossus* sp., *Solanum aviculare, S. ballisii, S. capsicastrum, S. carolinense, S. citrullifolium, S. gracile, S. ledorodorsum, S. mexicanum, S. nigrum, S. phasianium, S. pyracanthum, S. racemigerum, S. sanitwongsei, S. sisymbriifolium, S. triflorum, S. tuberosum, S. villosum*, and eggplant. The nymphs matured upon several varieties of tobacco, including Broadbent, Havana, White burley, Connecticut broadleaf, and Turkish.

Adult potato psyllids fed upon the following plants and laid eggs upon most of them, although the young failed to mature; however, on some plants, such as wanderberry, nymphs succeeded repeatedly in reaching the second to third instars: Giant petunia, snapdragon, wanderberry, pepper, lettuce, radish, peas, corn, table-beets, sugar-beets, mustards, cultivated morning glory, knotweed, vetch, *Atriplex rosea*, mallow, milkweed, sunflower, redroot, catnip, daisy, *Bassia hyssopifolia*, wild pansy, wild oats, dandelion, orchard grass, larkspur, marigold, spearmint, *Hibiscus trionum, Solanum flavum*, and *S. munistrum*.

These tests show that *P. cockerelli* will breed upon a number of plants which occur in various sections of the United States. The writers are indebted to Dr. S. P. Doolittle, Professor F. G. Weber, and Dr. R. W. Samson for the seeds of most of the solanaceous plants used in these tests.

GEORGE F. KNOWLTON and WYLIE L. THOMAS, *Utah Agricultural Experiment Station, Logan, Utah*

Wheat Bunt, A New Food for Grasshoppers.[1] Inspection of wheat fields for bunt (*Tilletia levis* Kuehn) revealed many bunted heads and bunt balls chewed by grasshoppers, thus facilitating the detection of bunt in both green and ripe heads of wheat. The grasshoppers chewed the wheat glumes and ate large parts of the bunt balls (Fig. 64). They left little except the bare rhachis of many bunted heads, making these heads resemble those damaged by loose smut (*Ustilago tritici* (Pers.) Jens.). Bunt balls chewed by grasshoppers were seen in many fields of Turkey, Jones Fife, and Marquis wheat in the western half of Montana in 1933. Similarly chewed bunt balls have been observed here during the preceding two years.

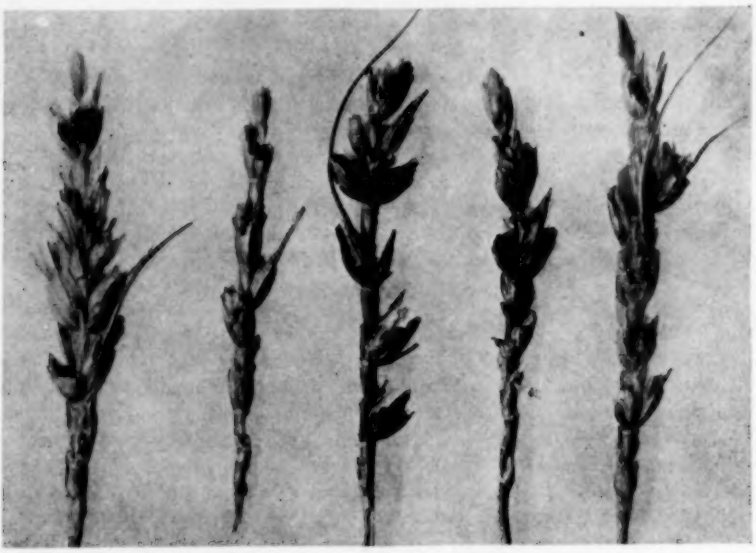


FIG. 64.—Bunt balls and heads of Turkey wheat chewed by grasshoppers in a field at Buffalo, Montana; July 24, 1933. X 91/55.

Grasshoppers collected on wheat heads were identified by Dr. J. R. Parker[2] as *Melanoplus mexicanus mexicanus* Saussure and *Melanoplus packardii* Scudder. They apparently preferred the bunt balls to the wheat kernels in those fields that contained much bunt. The prominent odor of bunt (stinking smut) probably aided the grasshoppers in selecting the bunted heads of wheat. Whitcomb and Bell[3] gave evidence that bunt balls contain 3.35 to 8.1 per cent more protein than the associated wheat kernels contain. Hence, the bunt balls may have served the grasshoppers as a high-protein food.

PAUL A. YOUNG, *Montana Agricultural Experiment Station*

[1]Contribution from Montana State College, Agricultural Experiment Station, Paper 39, Journal Series.

[2]Senior Entomologist, U. S. Dept. of Agriculture.

[3]Whitcomb, W. O., and E. J. Bell. The protein test in marketing wheat. Mont. Agr. Exp. Sta. Bul. 189, Table 8. 1926.

Green Peach Aphid Injuring Snapdragon. On November 24th, last year, the author's attention was called to injury to Snapdragons in the greenhouses of the Rhode Island State College at Kingston. At that time a series of tests had been carried on that definitely established the cause as neither fungus nor virus.

Damage to the Snapdragons was in the form of stunted growth, and ridges and papillae on the flowers and leaves accompanied by malformed and rolled leaves and less malformed flowers. The upper half of the plant was dense, there being scarcely any internode between leaves, and the flower head was partly concealed in the leaves. Each flower had from few to many papillae and ridges, the ridges sometimes connecting with one papilla and other times connecting two or more papillae. The general appearance of the papillae was very similar with that of the gall of the Chrysanthemum midge, being perhaps slightly smaller and more erect. They lack the hard central kernel, however. Aside from these unsightly growths the flowers were little if at all damaged.

The leaves showed similar injury to the flowers and in addition were curled and rolled. The rolling usually started at the tip of the leaf.

Some specimens of the aphids were collected and tentatively identified as *Myzus persicae* (Sulz.). These were later sent to Washington and the identification confirmed by P. W. Mason.

Apparently only the winged forms inflicted the damage as observations of the wingless forms failed to show that they were responsible for it. There is, of course the possibility that at the time the damage was done the plants, being younger, were tender and that the damage done is only inflicted on rapidly growing tissue. The winged forms were reported as quite numerous in the damaged section about the first week in November. At that time the house was fumigated. Examination of the injured plants invariably disclosed bodies of winged aphids which were, as far as could be determined, the same as those determined by P. W. Mason. Examination of healthy plants failed to show any bodies. At the time the observations were made there were only two winged individuals alive and these died so soon after being found that it was impossible to draw any conclusions from their behavior. The assumption that the damage was caused by the winged forms is based on the presence of their bodies on damaged plants, the absence of bodies on healthy plants and the absence of any other insect, living or dead, which could have caused the above mentioned injury.

Myzus persicae, the green peach aphid, has not been reported before as causing this type of damage to greenhouse plants in Southern Rhode Island so far as the author has been able to determine. Greenhouse men are apparently not familiar with the above injury. It is believed that this is the first time in this locality that this injury has occurred in any noticeable amount.

G. A. THOMPSON, JR.

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

APRIL 1934

The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication at $3.00 per page. There is a charge of $3.00 per page for all matter in excess of six printed pages, a part page counting as a full page, this limit not including acceptable illustrations. Photo-engravings may be obtained by authors at cost.

Separates or reprints, if ordered, when the manuscript is forwarded, will be supplied to authors at the rates given below. Note that the number of pages in a reprint may be affected somewhat by the make-up, and that part of a page is charged as a full page. Carriage charges extra in all cases. Shipment by parcel post, express or freight as directed.

One hundred separates or reprints at $1.50 per page or plate. Additional hundreds or less, 4 pages or less, $1.00; 5-8 pages, $1.50; 9-12 pages, $1.75; 13-16 pages, $2.00; 17-24 pages, $3.00; 25-32 pages $4.00. Covers suitably printed on first page only, 100 copies, or less $4.50; additional hundreds, or less, $1.75. Plates inserted, $1.75 per hundred or less. Folio reprints, the uncut folded pages (50 only), sixteen page signature, or less, $3.00. A discount of 10 per cent and 20 per cent from the above prices will be allowed on orders of 500 and 1000 reprints respectively.

A. A. A. S. Winter meetings, 1934-1935, Pittsburg: December 1935, St. Louis; Summer meetings, 1934, Berkeley, June 18-23; 1935, Minneapolis.

The Journal was started as the official organ of the Association. This policy has been consistently followed for more than a quarter of a century. The publication of the Proceedings in preference to other matter has been obligatory. Since the early days sections and branches have been organized, each a constituent part of the Association and with a more or less definite prior right in the publication of proceedings as compared with the independently submitted paper or the paper which has lost its place through delayed transmission and in effect has become an independently submitted paper. It seems difficult for some to realize that the listing of a title in the program or the intention to list does not of itself make that paper a part of the proceedings of the Association or of one of its subdivisions. A paper must be read, in abstract at least, if it is to appear in the proceedings and there can be little objection to the rule that a paper loses its place if the manuscript is not available when the proceedings are assembled for the printer. These conditions make it very difficult for the independently submitted paper or for one which has lost its place in the proceedings. The volume of organization matter, business and papers, is constantly increasing and this can not be avoided. Action upon questions of this nature is taken at a meeting by those in attendance. They naturally wish to see the papers they have heard in type. The presumption is that most of the papers read at meetings are as good as those sent in by parties unable to attend the meeting. It follows, that the independent paper is suffering from a progressively increasing handicap.

Current Notes

Dr. R. D. Bird of the Vernon B. C. Entomological branch laboratory has been transferred to Treesbank, Manitoba, to take charge of the field crop insect investigations, which position was made vacant by the death of Norman Criddle.

Mr. M. V. Anthony, formerly a graduate student at Ohio State University, has recently been appointed to a Crop Protection Institute fellowship, and stationed at the Experiment Station, New Haven, Connecticut. Dr. Philip Garman is directing the project.

An interesting survey made during the close of the 1933 field season of the white grub damage in the district of eastern Ontario showed that losses from this insect averaged about $188.00 per infested farm and the individual cases ranged from $23.00 to $875.00.

Dr. P. N. Annand, formerly in charge of the Sugar Beet Leafhopper Laboratory, Twin Falls, Idaho, and for the past year serving as Assistant Chief of the Division of Truck Crop and Garden Insect Investigations, has recently been promoted to Principle Entomologist and made Chief of the Division of Cereal and Forage Insect Investigations.

Mr. J. P. Barrett, M. Sc., has recently joined the staff of S. B. Penick & Company in the capacity of entomologist in their household and agricultural insecticide department. Mr. Barrett has had several years' experience in this particular field and will be stationed for the present at the New York headquarters of the company.

Notice has just been received of a new allotment of approximately $175,000 for a third unit to be added to the Public Health Service Laboratory at Hamilton, Montana, for study of tick-borne diseases. This will provide chiefly for experimental work with larger animals and for stock breeding of guinea-pigs and other laboratory animals. The second unit, increasing laboratory and office space, is practically completed and should be available for occupancy sometime in March.

Dr. Cornelius B. Philip, of the Public Health Laboratory, Hamilton, Montana, recently returned from St. Louis where he was detailed for four months in connection with insect transmission studies of encephalitis during the epidemic in that city. Visits were made by him incidental to these studies to Washington, D. C., the Illinois Natural History Museum, the Ohio State Museum, and the Universities of Chicago and Minnesota. Mr. Glen M. Kohls and Mr. Wm. L. Jellison of the same Laboratory recently returned from three months' leave at the University of Minnesota where they were doing graduate work.

A study of the overwintering population of the European spruce sawfly in Canada by the staff of the Fredericton Laboratory, during October, indicated that the potential emergence of this species in 1934, in the Gaspe peninsula, is greater than ever, and the complete defoliation of the majority of trees in heavily infested stands is threatened. This species of sawfly is the cause of much concern to the limit holders, and the International Paper Company have put five service operators in the field to report on conditions in their limits. Members of the laboratory staff collected 42,000 cocoons of the sawfly and forwarded them to the Belleville Parasite laboratory for the rearing of parasites.

The ninth annual meeting of the Cotton States Branch was held at Memphis, Tenn., on February 1, 1934. The attendance was good and an interesting program was presented with considerable informal discussion following the reading of papers which dealt with insects attacking crops grown in the southern region. The Chief of the U. S. Bureau of Entomology and the Acting Chief of the U. S. Bureau of Plant Quarantine, Messrs. Lee A. Strong and Avery S. Hoyt, attended the meeting and both responded to an invitation for remarks. Dr. Leiby, Chairman of the Branch, presented the past-president's diploma of the Association to Dr. Hinds who accepted it with fitting remarks, and then discussed the work of the Association during the past year. The following officers were elected for the ensuing year: Chairman—S. W. Bilsing, College Station, Texas; Vice Chairman—S. Marcovitch, Knoxville, Tenn.; Secretary-Treasurer (3 yr. term)—Oliver Snapp, Fort Valley, Ga.

The 30th quarterly meeting of the Entomological Club meeting of Southern California was held December 15th at the Elks Club, Alhambra, California, with 114 members present. Laboratory Fumigation with HCN and Other Gases was discussed by H. L. Cupples of the U. S. Bureau of Soils and Chemistry; and Insect Behavior by C. T. Dodds of Santa Paula. The remainder of the meeting was devoted to a symposium on Red Spiders, including Classification of Red Spiders by E. A. McGregor, United States Bureau of Entomology; the Pacific Red Spider in California by J. F. Lamiman, University of California, Berkeley; Citrus Red Spider Control by J. R. LaFollette, California Fruit Growers Exchange; and Selenium in the Control of Citrus Red Spider by C. F. Ladeburg, McLaughlin, Gormley King Co. A. M. Boyce reviewed the experimental work being carried on by the Citrus Experiment Station for red spider control, and A. F. Kirkpatrick covered experimental work being done by the Owl Fumigating Corporation along this same line.

The Texas Entomological Society held its sixth annual meeting at the Rice Hote, in Houston, Texas on January 26–27, 1934. The officers for 1933 were: president E. W. Laake, U. S. Bureau of Entomology, Dallas; vice-president, E. V. Walter, U. S. Bureau of Entomology, San Antonio; secretary-treasurer, M. A. Stewart, The Rice Institute, Houston. An informal smoker was held for early arrivals on the night of January 25th and the annual dinner was held on the night of the 26th with F. L. Thomas, Texas Agricultural Experiment Station, College Station, serving as toastmaster. The address at the dinner was given by Dr. Alfonso Dampf, Chief Entomologist, Mexican Plant Protection Service, Mexico, D. F., on "The Status of Entomological Exploration in Mexico." The special guest of honor and official representatives in attendance at the meeting were: Dr. Alfonso Dampf, Chief Entomologist, Mexican Plant Protection Service, Mexico, D. F., official representative of Sr. Don Francesco S. Elias, Secretary of Agriculture of Mexico; Dr. W. E. Hinds, Entomologist, Louisiana Agricultural Experiment Station, Baton Rouge, Louisiana, past-president of the American Association of Economic Entomologists and official representative of the American Association of Economic Entomologists; and Dr. M. D. Leonard, Research Entomologist for John Powell & Co. of New York City, Orlando, Florida, official representative of the Florida Entomological Society. The total attendance was fifty-three.

Horticultural Inspection Notes

A revision of circular BPQ-346, giving up-to-date information on the various State European corn borer regulations was issued by the Bureau of Plant Quarantine on March 15.

Transit inspection for the spring shipping season was begun in Kansas City, Seattle, and Portland, during February, and in Omaha and Spokane during the early part of March.

The Atlanta headquarters for the phony peach disease project of the Bureau of Plant Quarantine moved from the State Capitol to the newly constructed Federal building in that city the latter part of March. The new address is Room 414, New Post Office Building, Atlanta.

The gypsy moth was recently found in several additional townships in Pennsylvania, and Quarantine No. 24 of that State was accordingly amended, effective March 1, to include them. Parts of five counties, namely, Carbon, Lackawanna, Luzerne, Monroe, and Wayne, are now under regulation.

A "Synopsis of Federal Plant Quarantines Affecting Interstate Shipments" has been issued by the U. S. Department of Agriculture as Miscellaneous Publication 189. In addition to summarizing the Federal domestic quarantine regulations, it shows the quarantines affecting shipments from each post office in the United States.

Celery, oat and rye straw, and cosmos, zinnia, and hollyhock, were dropped from the list of articles restricted under the Nebraska State quarantine relating to the European corn borer under a revision which became effective on January 15. The former restrictions on vegetable and floral plants shipped from Ohio, Michigan, and Indiana, were also lifted.

For the protection of the white pines in the Conley State Forest Nursery at Greenbottom, W. Va., the State Commissioner of Agriculture recently established quarantine zones surrounding the nursery, and prohibited the planting or possession of currant and gooseberry plants in such zones. This nursery is located in Cabell County on the Ohio River.

In circular BPQ-358, issued by the Bureau of Plant Quarantine on March 15, the narcissus inspection, certification and treatment data for the calendar year 1933 are summarized. The statement shows 305,875,898 narcissus bulbs were inspected during the year, of which 59% were of the polyanthus type grown in the South, and 41% of the hardy daffodil type grown in the North. Most of the bulbs were certified on a basis of freedom from infestation. Those given hot water treatment numbered 15,291,197, while those fumigated numbered 18,578,820.

Mr. C. D. Lebert, formerly Assistant Entomologist and Quarantine Inspector of the Arizona Commission of Agriculture and Horticulture, has been made Nursery Inspector of the same Commission. Since his appointment, thorough examinations of the nurseries within the State of Arizona have been undertaken. This inspection has revealed a few outbreaks of the citrus red scale on ornamental stock held in lath houses by some of the nurseries. A serious attempt to eradicate these outbreaks has been made and at the present time the State Entomologist, D. C. George, states that he feels that the insect is under perfect control.

Oregon quarantines relating to the oriental fruit moth, the root-knot nematode, amd the cherry fruit fly were reissued in February. To the moth-infested territory were added the States of Kansas, Massachusetts, Michigan, Missouri, and Rhode Island, and provision was made for winter movement, under permit, of budwood and scions of the restricted fruit plants. The root-knot nematode quarantine had as its principal change the addition of spinach with roots to the list of restricted crops, and the deletion of asparagus and sweet potatoes. Under the intrastate quarantine relating to the cherry fruit fly, 5 more counties in Oregon were designated as infested with the fly, making a total of 12.

The alfalfa weevil quarantine proclamation of California was revised effective January 11, to provide for winter movement, under permit, of hay from infested areas of other States to the interior infested sections in California, when contained in tight railroad cars and shipped over designated routes. Certain modifications were also made in the certification requirements for hay movement from adjacent areas in Nevada to the border mountain and desert communities in California. An interpretation of the term, "tight railroad cars with all cracks and other openings sealed" will be furnished by the California officials "so that there may be a uniform understanding of what is required in that regard and in order to prevent the use of any inadequate or improperly sealed car."

The Arkansas State Plant Board issued a new circular (No. 1) dated January 31, giving such requirements and quarantines of the board as it was thought would be most commonly met with in the enforcement of the plant laws. The only material change appears to be in the rules relating to the sweet potato weevil, which were revised October 3, and sweet potatoes for eating purposes included. Two additional counties in Georgia (Glynn and Camden) are designated as infested with the weevil, and the permit requirements are extended to apply to the entire State of Oklahoma. Sweet potato plants and sweet potatoes for seed shipped to Arkansas from any State must be accompanied by a permit and certificate.

The South Carolina State Crop Pest Commission, effective on November 9, revised the phony peach disease regulations applying to both intrastate and interstate movement of the host plants. The infected area in that State was increased by the addition of one county, Bamberg, making a total of 17. Such areas in other States, as designated in the South Carolina regulations, now cover the entire States of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, and Texas, 8 counties in Illinois, 1 in Missouri, 6 in North Carolina, 1 in Oklahoma, and 9 in Tennessee. Certification is based on the usual requirements of a disease-free county, or disease-free environs, or borer-free stock. The States which have somewhat similar quarantines or policy requirements in effect at the present time, according to the records of the Bureau of Plant Quarantine, are Alabama, Delaware, Georgia, Louisiana, Mississippi, Oklahoma, and Tennessee.

The Arkansas State Plant Board is offering a reward of $10.00 for the arrest and conviction of persons violating the Arkansas Plant laws, or the rules of the Board, made under authority of same, the reward to be paid to the arresting officer. Mr. Paul H. Millar reports that there are now about forty constables and other officers on the watch for violators, and that very shortly this number will probably be doubled or trebled. The Board states that while this is a move against the bootlegger of nursery stock and other plants, it is probable that unless more care is used by legit-

imate nurserymen in complying with the details of the law, some of these may also be brought into court by officers and fined, for the Board will not be in position to interfere should a licensed nurseryman be arrested for a violation, even though it may be due to an oversight on the nurseryman's part, but must let the law take its course in any such case which might arise. The Board suggests, therefore that licensed nurserymen and dealers exercise unusual care in seeing to it that all their agents and representatives are provided with licenses, and that they carry them at all times, and that all packages of nursery stock sent out by truck, as well as by common carrier, have an inspection tag attached, and that a tag be attached to each package sold locally.

The Central Plant Board meeting was held in Lafayette, Indiana, on February 28th, at the Memorial Union Building at Purdue University. Seven States of the Central Board group were represented as well as a number of nurserymen from the National Association and the State associations of the Central States group. Mr. L. H. Worthley of the Bureau of Plant Quarantine, United States Department of Agriculture, discussed the Japanese beetle situation in detail with reference to the Central Plant Board States. Mr. Worthley stated that he planned on putting out traps again this year through some of the central States so that a close check could be kept on any possible spread. One of the topics receiving the largest amount of discussion was that relating to the requirements of States permitting the entry of nursery stock. This topic was discussed in detail by Prof. Ruggles of Minnesota, E. L. Chambers of Wisconsin and Frank N. Wallace of Indiana. Mr. Chambers of Wisconsin spoke of their State law with the reciprocal license provision embodied in it. This reciprocal provision was placed in the law in an effort to protect Wisconsin nurserymen from exorbitant fees and requirements from other States. The general opinion of those represented was that the high fees required by some States to ship in nursery stock were unjust and unless some reasonable solution could be found to the problem they would be compelled to take retaliatory measures. The Central Plant Board passed a resolution covering the subject as follows:—"*Resolved,* That the practice of some States charging fees for out-of-state nurseries be discontinued and the original certification be accepted in all States." Dr. O'Kane of the National Plant Board attended the meeting and talked on the possibility of getting more uniformity among the States, as well as the possibility of using a Federal tag for interstate shipments and using the State certification tag for State shipments. No action was taken on this matter at the meeting as it was felt by the group that it was better to go into the matter more thoroughly before taking any definite action. The officers elected were: P. A. Glenn of Illinois, Chairman; P. T. Ulman of Indiana, Secretary-Treasurer; George A. Dean of Kansas, to fill the unexpired term of K. C. Sullivan as National Plant Board Representative, and E. L. Chambers of Wisconsin, as the new member on the National Plant Board. The next meeting of the Central Plant Board will be held at Champaign, Illinois, in connection with the Central States Entomologists meeting about the first week in March, 1935.

Apicultural Notes

By co-operation between the Beekeepers of England and the Agricultural Research Council, financial arrangements have been made to carry out at the Rothamsted Experimental Station, an investigation of Foul Brood Diseases of Bees which have hitherto caused considerable trouble and loss. Dr. H. L. A. Tarr has been appointed an investigator. Dr. Tarr obtained his B. A. and M. A. degrees at the University of British Columbia and his Ph.D. in the Department of Bacteriology at McGill University in 1931. Since then he has been working at bacteriological problems in the Biochemical School at the University of Cambridge with an 1831 Exhibition Overseas Travelling Scholarship and an External Research Studentship at Emmanuel College.

Mr. E. L. Chambers, State Entomologist, Wisconsin, reports that the Wisconsin legislature has recently placed an occupational tax on beekeepers. Although this law may help in locating bee yards and in stimulating organization to protect the beekeeping industry, unfortunately the funds derived from the tax are not allotted specifically to bee inspection work. The new law provides for an annual tax of twenty-five cents for the first hive and ten cents for each hive in excess of one. After the expenses for collecting the tax have been deducted, twenty per cent of the balance goes to the town, city, or village in which the bees or bee equipment are kept, and the remainder to the State. The new law also specifies that applications to move bees or used equipment must be made before the first day of June of each year.

DIRECTORY OF SUPPLIES AND EQUIPMENT USED AND RECOMMENDED BY ENTOMOLOGISTS

The following directory is compiled and published (1), for the convenience of entomologists in knowing where supplies and equipment ordinarily used in connection with research and control of insect pests can be obtained and subsequently recommended, and (2), for the convenience and financial aid to producers and sales agencies in bringing their products to the attention of those interested.

The publishers of the JOURNAL OF ECONOMIC ENTOMOLOGY believe the supplies and equipment listed in this Directory to be as represented by the manufacturers and sales agencies and recommend the use of this Directory whenever and wherever practicable.

JOURNAL OF ECONOMIC ENTOMOLOGY,
A. I. BOURNE, Business Manager.

INSECTICIDES, ADHESIVES AND SPREADERS

FUMIGANTS AND EMULSIENTS

Ethylene Oxide, Carboxide and the Ethylene Dichloride Mixture—The safe fumigants for foodstuffs, clothing, furs, furniture, grain, etc.
Triethanolamine—An excellent emulsient for contact insecticides.
BOOKLETS WILL BE SENT UPON REQUEST
Carbide & Carbon Chemicals Corporation
30 East 42nd Street, New York, N. Y.

RED ARROW INSECT SPRAY

(Pyrethrum Soap)
and other non-poisonous insecticides are fully described in our full page advertisement on page 8.
McCORMICK & CO., INC.
Standardized Liquid and Dust Pyrethrum Products.
BALTIMORE, MD., U. S. A.

"BLACK LEAF 40"

World Renowned Aphis Specific.
Officially recognized dip for sheep and cattle scab in U. S. A.
Kills poultry lice when "painted" on roosts
Tobacco By-Products & Chemical Corporation
INCORPORATED
Louisville, Kentucky

PENETROL

An activator for nicotine spraying solutions.

NICOTROL

A complete self-spreading nicotine spray made by combining nicotine with Penetrol.

KAY-FRIES CHEMICALS, INC.
180 Madison Ave., New York

SODIUM FLUOSILICATE—commercial and
LEVOSOL FLUOSILICATE DUSTING POWDER—light and extra light specially prepared grades of Sodium Fluosilicate for dusting on plants
SYNTHETIC CRYOLITE high-test, light and fluffy
ALL FLUOSILICATES AND FLUORIDES
THALLIUM SULPHATE
JUNGMANN & CO., Incorporated
155 Sixth Ave., New York, N. Y.

B. G. PRATT CO. NEW YORK, N. Y.

SCALECIDE—the premier miscible oil for scale since 1904.
SULFOCIDE—a sulphur compound for fungous troubles.
SULFOCIDE AND SCALECIDE COMBINATION for most citrus diseases and insects.
SAMPLES AND LITERATURE ON REQUEST

CYANEGG (Sodium Cyanide 96–98%)
For HCN fumigations in industrial structures, ships, railroad equipment and houses.
TRICHLORETHYLENE . . . for use in fly sprays and as insecticide and fumigant.
LITERATURE SENT ON REQUEST
THE ROESSLER & HASSLACHER CHEMICAL COMPANY, Inc.
Empire State Bldg.,
350 Fifth Ave., New York, N. Y.

WILSON'S O. K. PLANT SPRAY

"Why Bugs Leave Home"
The Insecticide Supreme—A Contact Spray
Wilson's Awinc Spray
"Pyrethrum at its Best"
Wilson's Scale-O
"The Superior Miscible Oil Spray"
Wilson's Fung-O
"Complete Fungicide"
ANDREW WILSON, INC., Springfield, N. J.

"CORONA DRY" ARSENATE OF LEAD

A testimonial trail across the country is rendered by thousands of fruit growers for this famous Arsenate of Lead. Also manufacturers of a full line of insecticides, fungicides and seed disinfectants.
PITTSBURGH PLATE GLASS COMPANY
Corona Chemical Division—Milwaukee, Wis.

AGRICULTURAL SPRAY MATERIALS

PYROX (Combined insecticide and fungicide
NICOTINE PYROX
ARSENATE OF LEAD
CALCIUM ARSENATE
LIME SULPHUR (Liquid and Dry)
BORDEAUX
COPPER LIME DUSTS
Manufactured by
THE BOWKER CHEMICAL COMPANY
Bowker Building, 419 Fourth Avenue
New York, N. Y.

INSECTICIDES, ADHESIVES AND SPREADERS—Continued

DENDROL DORMANT SPRAY OIL

High rating given by Experiment Stations—in actual tests—for fruit tree leafroller, scale, European red mite, and other pests. Users prefer Dendrol because of ease in handling, mixing with hard water, for maximum coverage, and extreme effectiveness.

STANDARD OIL CO. (Ind.) Chicago, Ill.

C. P. O. SOLID (60% SOAP)
C. P. O. LIQUID (40% SOAP)

A dependable, non-poisonous, odorless insecticidal soap spreader for nicotine and pyrethrum. Tests made by Experiment Stations have demonstrated unique uses for this product. Information on request.

CRYSTAL SOAP & CHEMICAL CO., Inc.
6300 State Road, Philadelphia, Pa.

SPRAYING AND DUSTING MACHINERY

Bean sprayers and dusters for orchards and crops in a variety of sizes for any requirements.
Bean leads, others follow
JOHN BEAN MFG. CO.
Division Food Machinery Corporation
Lansing, Mich. San Jose, Calif.

HIGH DUTY SPRAYERS
Manufactured by
FITZHENRY-GUPTILL CO.,
135 First Street East Cambridge, Mass.

TREE EXPERTS

SCIENTIFIC TREE CARE

Whether spraying, feeding, pruning, cavity work, tree moving, or other tree care. Davey Tree Surgeons will handle it successfully, economically and scientifically.

THE DAVEY TREE EXPERT COMPANY
Main Office, Kent, Ohio

CHAS. F. IRISH CO. ARBORISTS

Diagnosis, aeration, feeding, spraying, tree moving—every operation necessary to a complete national arboreal service—20 years' experience.

Cleveland, Ohio and Detroit, Mich.

WHERE SCIENCE RULES - -
THE BARTLETT WAY

A complete tree health service, founded a developed on scientific methods of practice.

THE F. A. BARTLETT TREE EXPERT CO
STAMFORD, CONN.

LABORATORY AND MUSEUM SUPPLIES

Entomological supplies of all kinds including the American Entomological Co. insect pins, Schmitt and Hood insect boxes, insect nets, etc. Write for catalogue D-43.
Ward's Natural Science Establishment, Inc.
Box 24, Beechwood Station, Rochester, N. Y.